EVALUATING CONSTRUCTION ACTIVITIES IMPACTING ON WATER RESOURCES

PART IV

MARINE CONSTRUCTION PROJECTS

APRIL 1986

Environment
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Ontario

EVALUATING CONSTRUCTION ACTIVITIES IMPACTING ON WATER RESOURCES

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MINISTRY OF THE ENVIROMNENT
WATER RESOURCES BRANCH

APRIL 1986

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FOREWORD

In 1976 the Ministry of Environment published the handbook Evaluating Construction Activities Impacting on Water Resources as an aid in the assessment of the environmental impact of construction activities. Information gained since 1976 now warrants a revision of the original document.

The revised guidelines have been divided into five parts, and are presented as five separate publications as follows-:

Evaluating Construction Activities Impacting On Water Resources:

- Part I — Guidelines for construction of hydrocarbon transmission and distribution pipelines crossing water courses (March, 1984);
- Part II — Guidelines for construction of highways and bridges (March, 1984);
- Part III — Guidelines for dredging and dredged material disposal (1986);
- Part IV — Guidelines for marine construction projects (April, 1986);
- Part V — Guidelines for small scale waterfront projects (April, 1986).

Marine construction activities undertaken by the provincial and municipal governments are subject to the Environmental Assessment Act. Federal activities may be reviewed under the Federal Environmental Assessment and Review Process.

These guidelines (Marine Construction Projects - Part IV) have been compiled to aid proponents and reviewers by providing a basic information package of water resources concerns for use in the impact assessment process.

The aim is to provide assistance in both anticipating potential problems and in planning adequate mitigative measures.

"Part IV - Marine Construction Projects" has been prepared under contract for the Water Resources Branch.

INTRODUCTION

Environmentally sound marine construction practice requires that every effort be made to preserve the physical and biological integrity of Ontario's waterbodies in accordance with the provincial goals -- "To ensure that the surface waters of the Province are of a quality which is satisfactory for aquatic life and recreation". (Ontario Ministry of the Environment, 1978)

The use of the term marine construction in this document refers to construction activities in large lakes and rivers rather than oceans and seas. From a construction practice standpoint the problems or difficulties encountered in working in Great Lakes and other large freshwater environments can be as great as the oceanic 'marine' environment.

Marine construction projects range from small shoreline stabilization works to large scale lakefill construction and oil and gas pipeline crossings. Just as the engineering aspects of a project require careful site-specific analysis, so do environmental considerations. Aquatic environments around Ontario vary widely and physical characteristics alone are not a reliable indicator of the sensitivity of biological components.

The following chapters outline the potential impacts of various marine construction activities on water resources and appropriate measures to mitigate adverse impacts. Additionally, each chapter will provide the information required to assess the potential impacts from specific projects.

By their nature, marine construction activities impact on the shore environment where the land/water interface supports a complex web of biological and geomorphological processes in dynamic equilibrium. The goal of this document is to illustrate the impact any modification to the nearshore environment can have on that complex interrelationship and indicate ways in which the impact can be minimized.

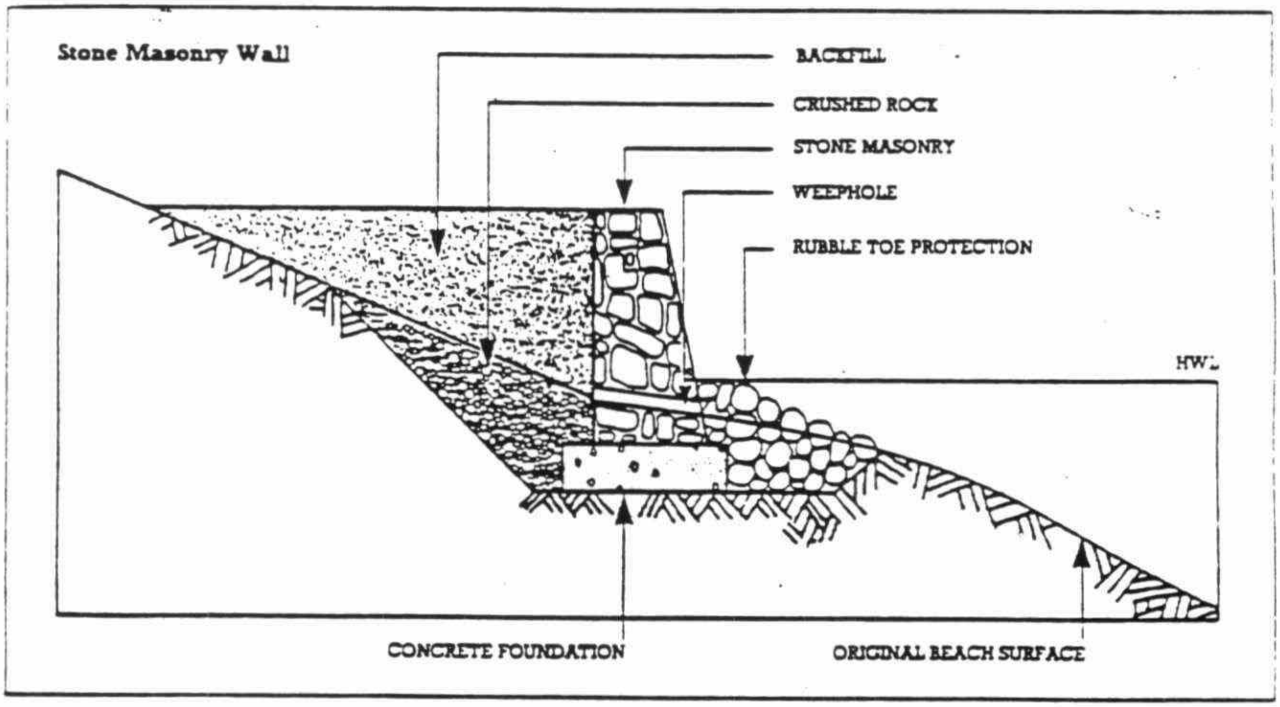
CHAPTER ONE
SHORELINE STABILIZATION PROJECTS

1.1 DESCRIPTION

This chapter will concentrate on the impact of making structural modifications to achieve shoreline stability.

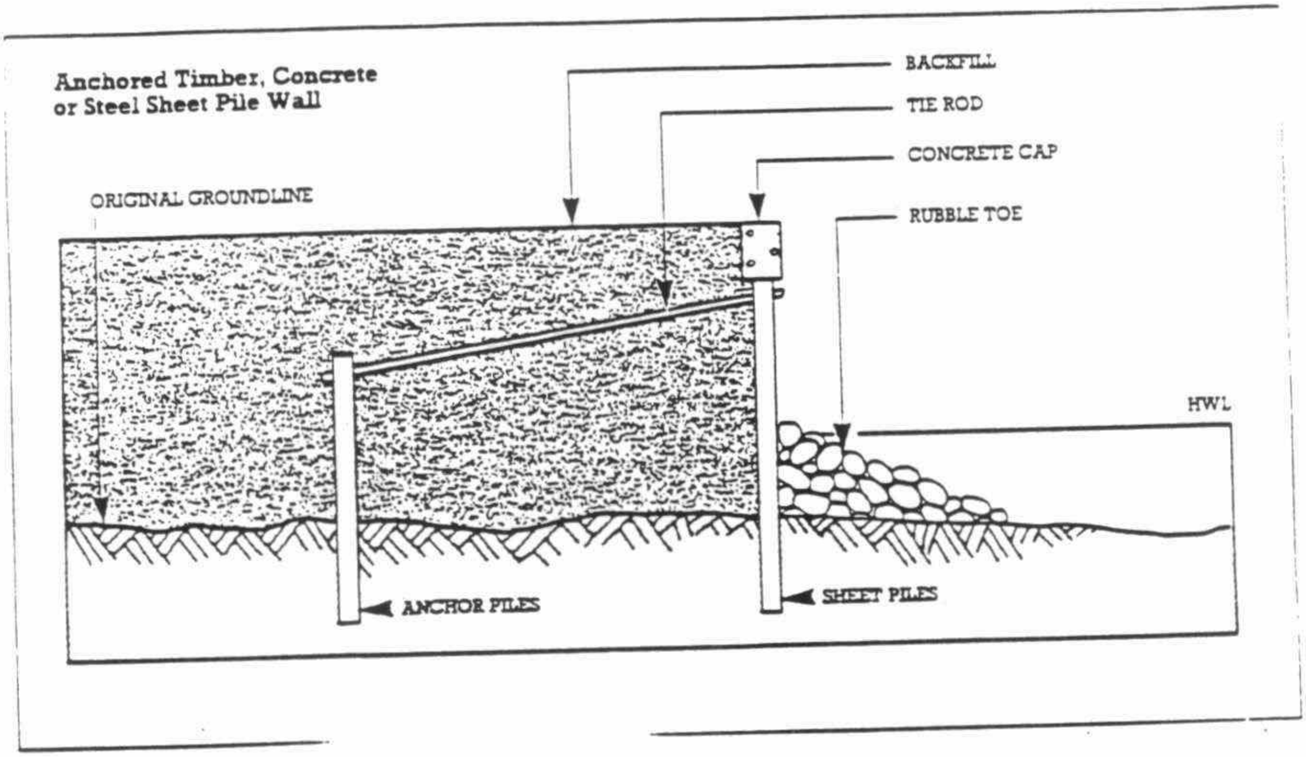
In situations where it is most appropriate to apply structural modifications to prevent shoreline erosion, the most common methods of shore protection are described below.

a) Bulkheads are vertical or nearly vertical structural walls designed primarily to retain fill but providing some protection against waves. They tend to reflect waves rather than dissipate their energy.

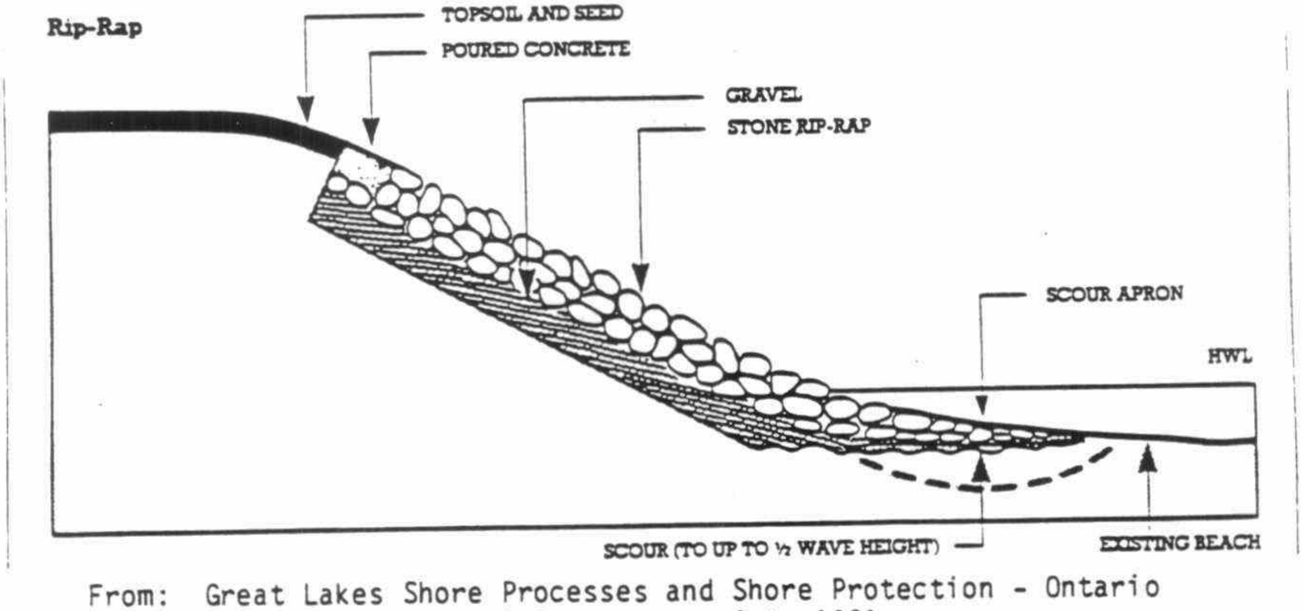


From: Great Lakes Shore Processes and Shore Protection - Ontario Ministry of Natural Resources - Oct. 1981

FIGURE 1.1.A TWO BULKHEAD DESIGNS



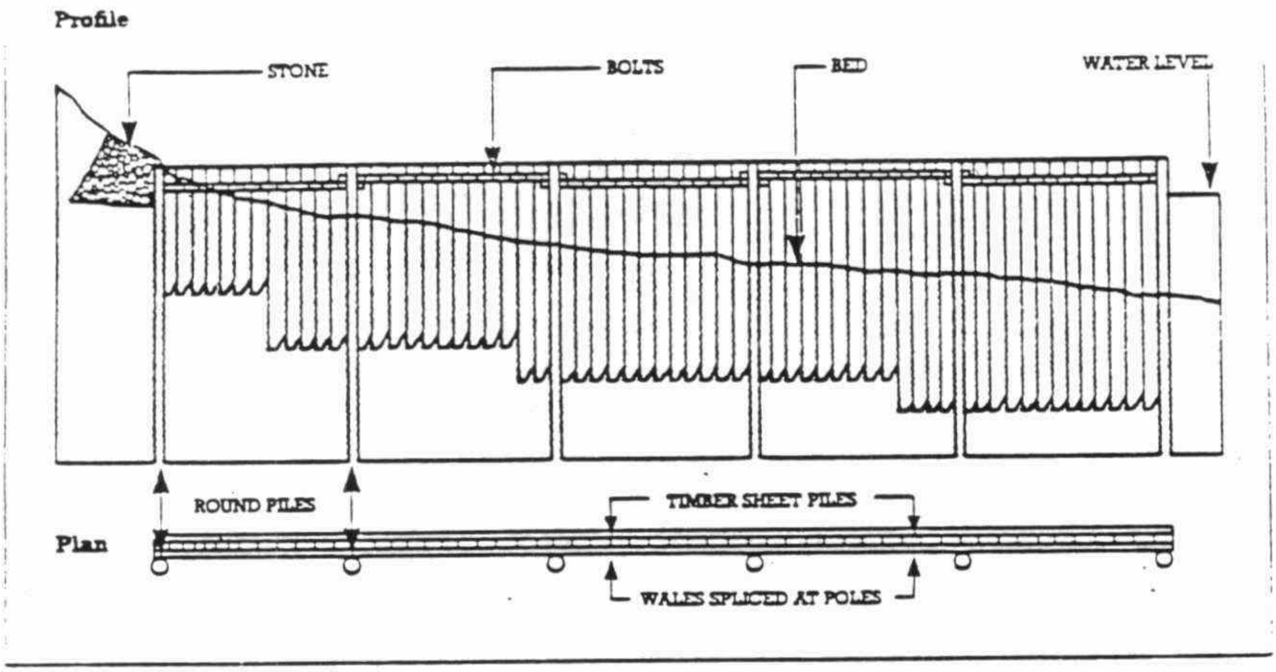
b) Revetments are sloping protective facings (commonly of rip-rap, concrete slabs or gabion baskets) designed to protect the underlying bank from erosion. They dissipate wave energy better than bulkheads.



From: Great Lakes Shore Processes and Shore Protection - Ontario Ministry of Natural Resources - Oct. 1981

FIGURE 1.1.B A RIP-RAP REVETMENT

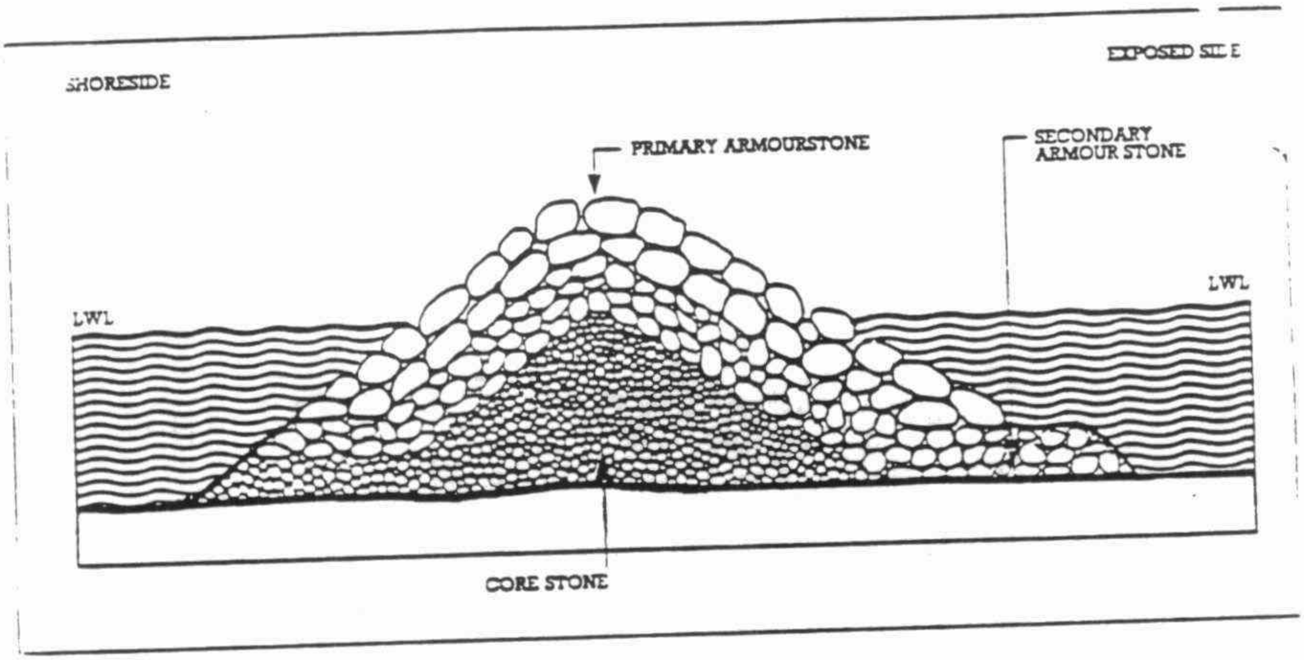
c) Groynes are walls built lakeward from and usually perpendicular to the shoreline. Typically they are built of steel or timber piles or stone and may be permeable or impermeable. They are intended to deflect waves, littoral currents and to capture littoral material to build or maintain a beach.



From: Great Lakes Shore Processes and Shore Protection - Ontario Ministry of Natural Resources - Oct. 1981

FIGURE 1.1.C TIMBER GROYNE

d) Breakwaters are walls built to shelter a shoreline from wave action. They may be connected to the shoreline or placed offshore. Their expense is usually justified only when the sheltered water it creates is needed for a harbour. Recently floating tire breakwaters have been deployed although they are only effective for short period waves.

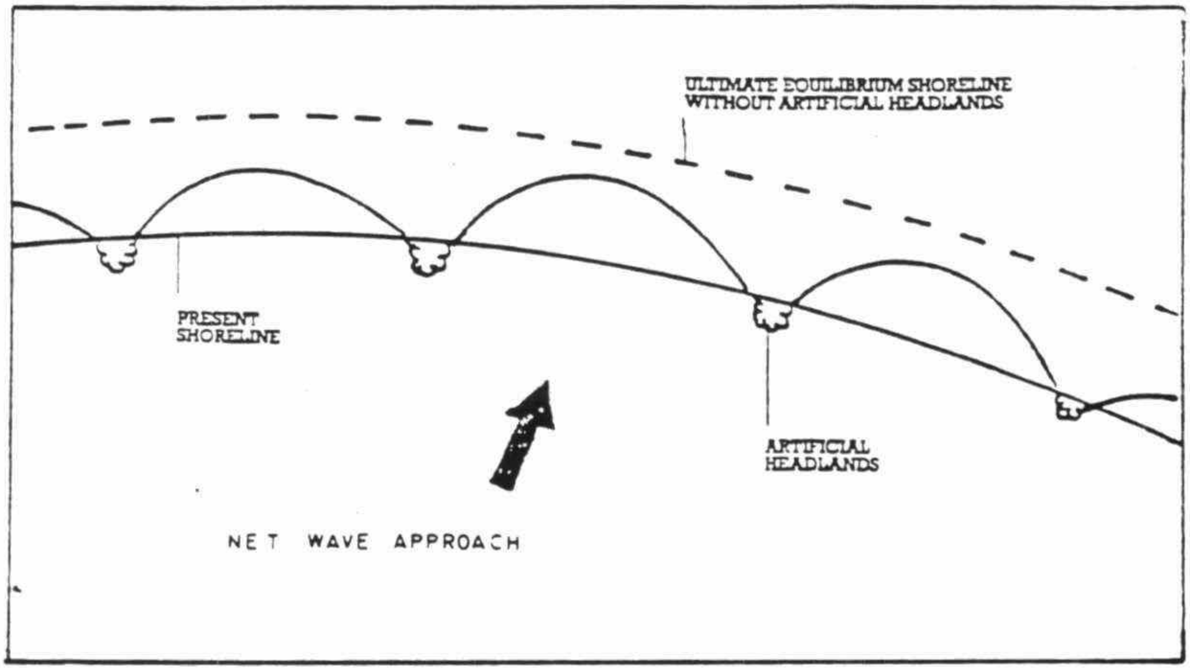


From: Great Lakes Shore Processes and Shore Protection - Ontario Ministry of Natural Resources - Oct. 1981

FIGURE 1.1.D OFFSHORE BREAKWATER

The best form of shore protection is an energy absorbing beach, but most problems in the Great Lakes occur during high water levels which diminish the effectiveness of beaches to protect adjacent land areas from erosion. Protection can be enhanced by artificially raising the beach elevation with imported fill of the correct grain size (often dredged from offshore). Protection is most effective with the use of a perched beach retained by a sill.

Natural shorelines that have long term stability are usually comprised of curved beaches between non-erodible points of land. The beaches are oriented perpendicular to the net wave approach. The addition of armouring to lengthen and reinforce existing promontories, particularly at littoral drift nodal points, shows some promise as a shore protection measure. On a smaller scale, long shallow beaches can be subdivided into a series of shorter, more sharply curving beaches between artificial hardpoints to minimize littoral transport out of the system. The construction of large artificial hardpoints will be discussed in more detail in Chapter 3 Lakefills and Piers.

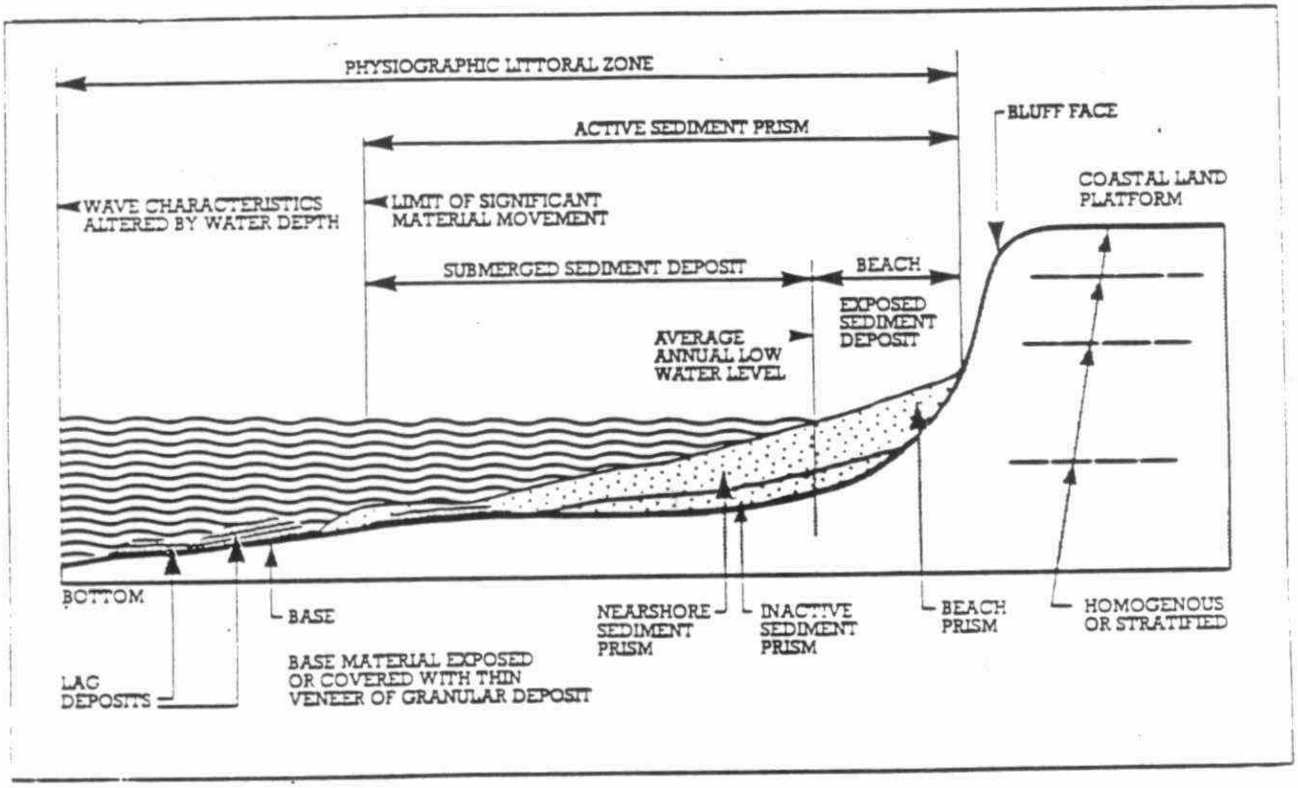


From: Great Lakes Shore Processes and Shore Protection - Ontario Ministry of Natural Resources - Oct. 1981

FIGURE 1.1.E ARTIFICIAL HEADLANDS

1.2 SHORE PROTECTION IMPACTS

Shore protection measures are designed to subdue the erosion forces of wind and water. On the Great Lakes the greatest erosion factor is exposure to wind generated waves. This is often compounded in areas of high bluffs with bank instability due to groundwater seepage.



From: Great Lakes Shore Processes and Shore Protection - Ontario Ministry of Natural Resources - Oct. 1981

FIGURE 1.2.A LITTORAL ZONE

Natural shorelines are dynamic in that they continually readjust to accomodate different water levels, the changing direction of incident waves, changes in soil characteristics of the shoreline itself, and modifications to nearby shorelines. In the nearshore zone of the Great Lakes, wave energy moves littoral material (supplied by beaches, bluffs and tributary inputs) in a longshore direction. Often there is a net littoral drift in a given direction as a result of the predominant direction of wave energy (a product of wind direction, duration and fetch) for any one location. It must be noted that the predominant wave energy direction is not necessarily the same as the predominant wind direction.

The littoral drift helps to maintain beaches in a dynamic equilibrium and thus contributes to shore protection. Blocking the littoral drift will result in accumulations of sand updrift and beach starvation (even disappearance) downdrift.

These dynamic characteristics of shorelines work against the application of fixed structural modifications. It becomes particularly difficult to protect a small part of a shoreline without adversely affecting adjacent areas.

Since littoral drift is the direct result of wave energy against the shoreline, most shore protection measures designed to reduce the incident wave energy or isolate the shoreline from that energy (or both) necessarily have some effect on littoral drift.

The actual construction of most common shore protection measures described in section 1.1 has little direct impact on water quality. Materials placed in the water (steel piles, precast concrete, rock and timber) are, by design, durable and inert. Some localized erosion may result from providing access to the work site, particularly in bluff areas.

More important water quality changes will result from the effect of stabilization of the shoreline. In areas where fine grained soils had been eroding, a net improvement in water quality may result if down drift erosion has not been enhanced.

Downdrift erosion is the most common problem associated with shore protection installations. Water quality deterioration can be severe in instances where protective beaches are destroyed and bank erosion commences.

The littoral zone is the most biologically productive zone of a lake. The numbers of taxa and the relative density of fauna are directly proportional to the stability of the substrate (Barton and Hynes). Areas characterized by high rates of erosion will have more sparse communities than stable shorelines although they may be locally important. Wave action and currents are necessary to prevent siltation of coarse substrate fish spawning areas.

1.3 IMPACT MITIGATION

As can be appreciated from the previous section on shore protection impacts, the most appropriate mitigation is to produce a design that minimizes off-site impacts, particularly downdrift erosion.

Consideration must be given to long term implications (including water quality) of structural failure. This consideration may require answers to questions such as: Will the shoreline revert to its original condition or, more likely, will new (and possibly emergency) measures be required to protect a new land use? Could structural failure lead to water quality degradation by exposing on-shore facilities (such as oil tanks, waste treatment lagoons) to wave attack?

In addition to inappropriate design of the shore protection measures discussed, stopgap measures which are prone to failure should be discouraged. For example, earth fill dumped down a bank is easily eroded and aggravates water quality problems. Coarse fill such as rock and rubble could be effective but the quantities required for a

high bluff will be much greater than if they are positioned as a designed revetment at the toe. Gabion baskets have proved unsuccessful in harsh wave environments particularly in groyne applications and revetments. Longard tubes can be ripped open by ice and floating debris but may be suitable for emergency, short-term protection.

Any application of bulkheads or revetments should be backed by a filter layer of gravel or filter cloth to minimize washout and settling while relieving pore water pressure.

Sandbag installations will be much more effective if the bags are filled with a sand cement mix.

For large scale projects, where the interaction of wave diffraction and refraction make analysis of the shore processes difficult, a physical model of the site can be useful and cost effective.

It is always preferable to consider complete shoreline physiographic units rather than individual properties. Property owners should approach shore protection problems as a community to avoid expensive and counterproductive individual "solutions".

Any shore protection project should be monitored regularly as periodic maintenance will always be required.

1.4 INFORMATION REQUIREMENTS FOR REVIEWERS

(The following list is provided only as a guide. Specific requirements will be determined on a case by case basis by the appropriate MOE regional office.)

- o Identify shoreline type and geomorphology including strati graphy of nearshore zone deposits.
- o Describe onshore and offshore topography.
- o Direction and characteristics of littoral drift.
- o Historical information on erosion rates.
- o Wind, wave and current climate at site on a monthly basis preferably covering a 20 year period.
- o Water level frequency information under calm and storm conditions.
- o Ground water information.
- o Water quality characteristics.
- o Aquatic habitat characteristics.
- o Intakes in vicinity and surrounding land use.
- o Design details of proposed structures including design life maintenance requirements.
- o Proposed land use modifications.
- o Proposed method of construction and scheduling.
- o Economic restraints.
- o Anticipated off-site impacts.

1.5 SUPPLEMENTARY INFORMATION SOURCES

- Great Lakes Shore Processes and Shore Protection, Ontario Ministry of Natural Resources, October 1981.
- Great Lakes Shore Management Guide, ed. by D.L. Strelchuk, Fisheries and Oceans Canada, Environment Canada, Ontario Ministry of Natural Resources, October 1981.
- Bioengineering for Land Reclamation and Conservation, Hugo Schiechtl, 1980.
- Low Cost Shore Protection, Report on the Shoreline Erosion Control Demonstration Program, John G. Housley, U.S. Army Corps of Engineers.
- The Role of Vegetation in Shoreline Management, Great Lakes Basin Commission and Environment Canada, 1977.
- Shore Protection Manual, U.S. Army Corps of Engineers, Coastal Engineering Research Centre, 1977.
- Report of the Lake Shore Erosion Conference, The Niagara-Toronto Lake Shore Protective Association, March 10, 1948.
- Vegetation for the Rehabilitation of Pits and Quarries in Ontario, C.J. Heeney, et al., Ontario Ministry of Natural Resources.
- Wave Zone Macrobenthos of the Exposed Canadian Shores of the St. Lawrence Great Lakes, Dr. Barton and N.B.N. Hynes, Journal of Great Lakes Research, Vol. 4, March 1978.

CHAPTER TWO
SHORELINE DREDGED MATERIAL DISPOSAL

2.1 DESCRIPTION

Concern about the water quality implications of open water disposal of contaminated dredged material has led to the construction of containment facilities throughout the Great Lakes.

Since the mid 1970's the Ministry of the Environment has evaluated the quality of sediments according to physical, chemical and biological criteria as described in Appendix I. Confined disposal is required for dredge spoils which fail to meet guidelines for open water disposal. Details on dredging and dredged material disposal are outlined in a separate document (Evaluating Construction Activities Impacting on Water Resources. Part III Guidelines for Dredging and Dredged Material Disposal).

Some disposal facilities have been constructed on land but many are extended into the nearshore zone due to the difficulties and expense of acquiring suitable up-land sites or the desire to create additional land.

Confined or semi-confined shoreline disposals have been built at most of the major Ontario Great Lakes harbours. Facilities built in the mid 1970's were generally sized for one time use but the trend now is to size facilities to accomodate five to ten years' quantities maintenance dredging.

Typically the disposal site is a one or two cell structure built within 1 km of the dredging area to facilitate cutter suction hydraulic dredging with pipeline disposal. Where no site that close was available, dyked areas within 5 km have been constructed to provide at least partial confinement for material transported in bottom dump scows.

Confined disposal sites are used to prevent contaminants in dredge spoils from impairing water quality or adversely affecting biota. The degree of confinement required is determined by the nature of the contaminant. For toxics which may bioaccumulate, the disposal site should be designed to eliminate any pathways to biota (eg. direct access, uptake into plants, water runoff or leachate). For relatively innocuous contaminants like wood fiber, it may be adequate to temporarily retain the dredge spoils within pervious dykes.

2.2 SHORELINE DISPOSAL IMPACTS

a) Land Use

A shoreline disposal facility may impact uses on many hectares of surrounding land and/or water altering the physical character of a

physical character of a site substantially. While the site may only be in active use for a few years, it will probably be necessary for it to continue its function (isolating contaminants from the biosphere) indefinitely. Long term land and water use of the area will thus be constrained to some degree.

b) Physical

The physical impact of a shoreline disposal can be greater than the shoreline stabilization schemes previously discussed in Chapter 1. Since the disposal represents a new shoreline it will require some form of shore protection.

Depending on the new shoreline configuration and the distance offshore, the disposal could disrupt littoral processes and some nearshore aquatic habitat will be lost as the nearshore slope is replaced with a land area with steep sloping armoured sides. Even in instances where the disposal is only partially confined, the new contaminated substrate will lead to a benthic species shift that may be undesirable.

c) Water Quality

There are direct water quality impacts from both the construction and operation of confined disposals. During construction, dykes will be built to enclose the site. In extreme cases, soft sediments may have to be dredged to provide a stable base but generally the dyke will be built by directly dumping rock or earth material in the desired configuration. The water quality impacts which are normally minimal for rock fill and greater when earth fill is used, includes turbidity resulting from the loss of fine material to the water column. Any contaminants associated with the fill will also be released to the water column.

2.3 DISPOSAL IMPACT MITIGATION

a) Land Use

Long term land use must be considered at the site selection stage. Consideration should be given to both the operational characteristics of the site and its ultimate use. Even contaminated dredge spoil can be a resource to be utilized in creating an end use. Those uses have included park land, marina facilities, industrial land and wildlife areas.

b) Physical

The most effective way to mitigate the physical impact of a shoreline disposal is to minimize its impact on the littoral zone. The size and shape should not block littoral drift.

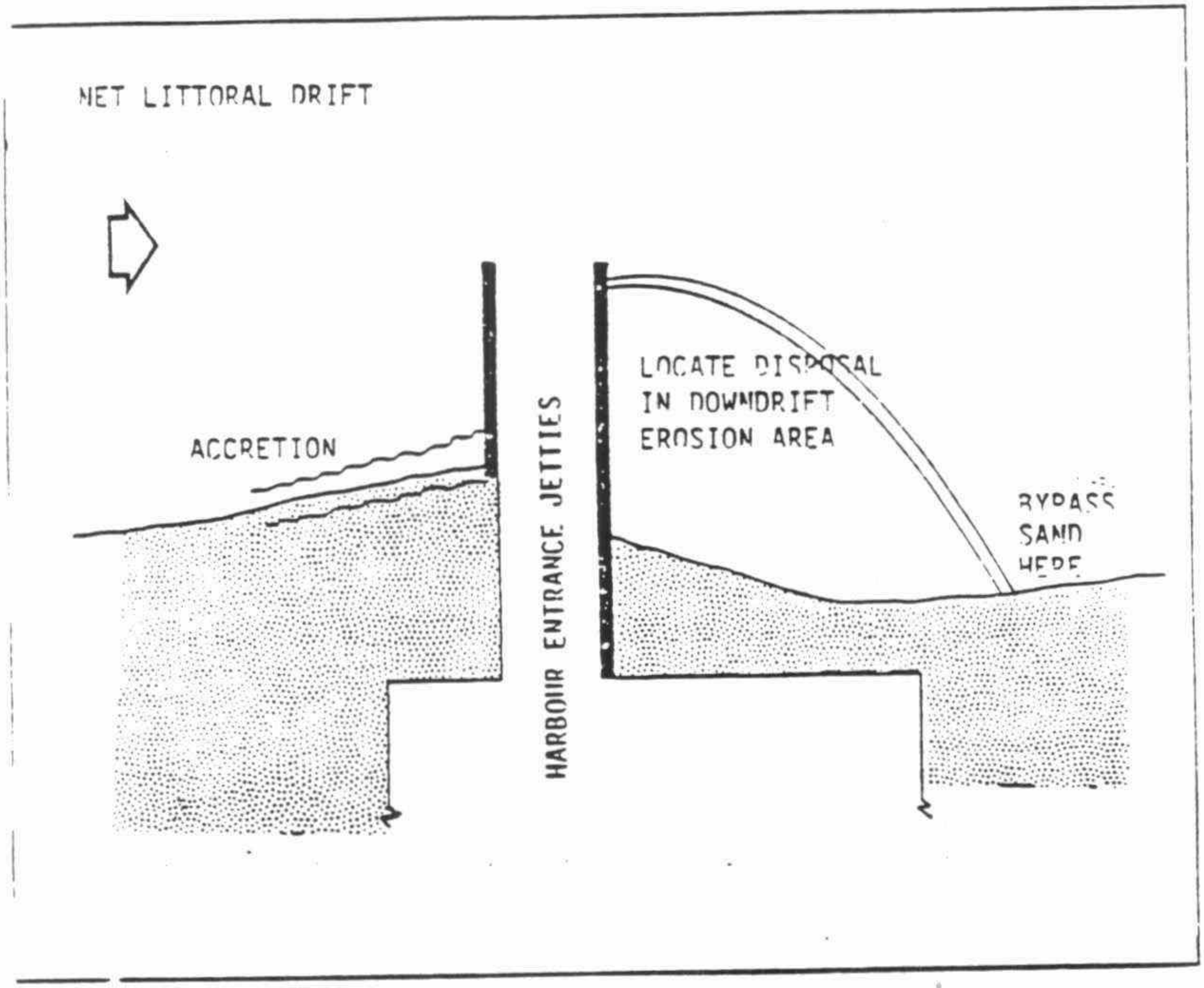


FIGURE 2.3.A DISPOSAL LOCATION

The new shoreline should be stabilized without enhancing downdrift erosion. Siting should preclude the burial of important aquatic habitats like marshes or fish spawning areas.

c) Water Quality

Sites which are to be filled with contaminated dredged material over a long period should be compartmentalized to minimize exposure to the contaminants. This is especially important for semi-confined disposals which remain accessible to aquatic organisms. Gaps into the disposal compartment should be close when not actually in use for barge traffic. Closure can be effected by a temporary berm for a prolonged period of disuse or various arrangements of floating barriers.

The key to preventing water quality degradation during disposal site construction is to prevent losses of the dyking material. This

is seldom a problem for rock or slag dykes but earth dykes will require prompt application of erosion control measures.

The supernatant should not degrade the quality of the receiving watercourse below the Ministry of the Environment water quality objectives outside of a defined mixing zone. The supernatant quality can be improved by providing sufficient settling time to remove particulate associated contaminants or by filtering it through porous fabric or granular materials sized to trap the clay and silt particles. It may be possible to avoid direct overflow altogether if the rate of filling does not exceed the ability of permeable berms to pass the flow.

SPOIL

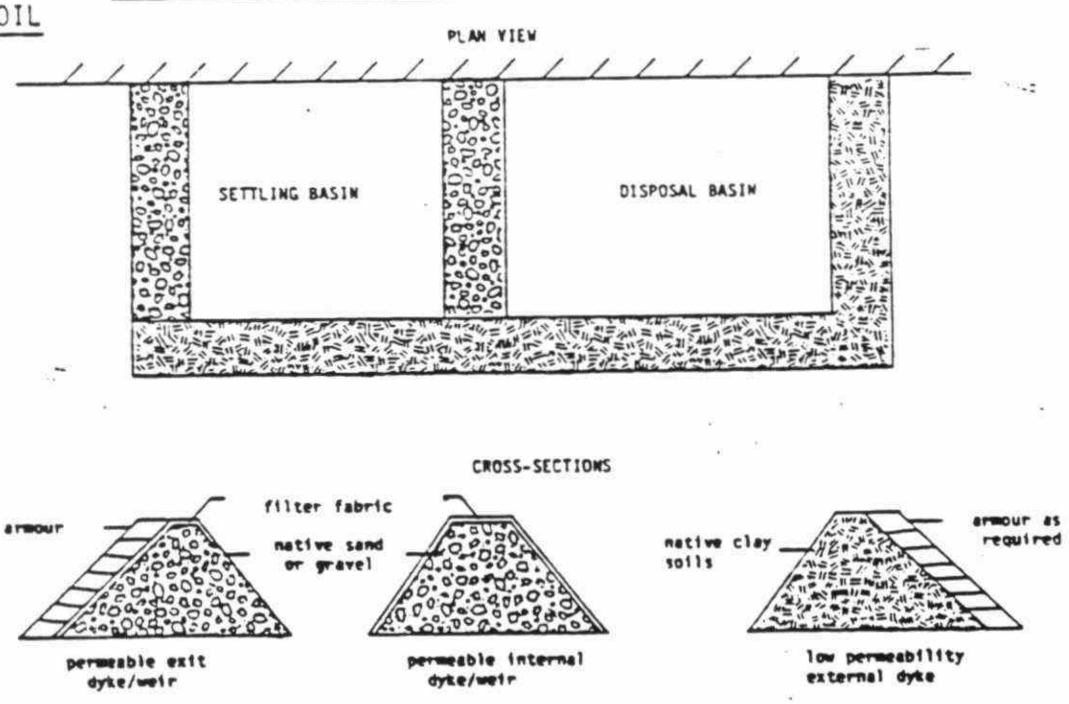


FIGURE 2.3.B SCHEMATIC OF DISPOSAL FOR CONTAMINATED HYDRAULIC DREDGE SPOIL

The amount of water to be disposed of is drastically reduced if the spoils are handled mechanically rather than hydraulically. For hydraulic operations the disposal should incorporate an effluent settling basin to provide adequate settling when the main cell is full. Studies of confined disposal basins on the St. Clair River found that mercury losses through rock dykes lined with gravel and filter fabric were at least as low as the losses via the direct overflow from a secondary settling lagoon. Losses at the same site when spoils were placed mechanically were negligible.

Adjustable weirs, if properly serviced will provide better effluent quality than simple outfall pipes. Good performance has been achieved by incorporating screens of filter fabric into the weir. The weir should be positioned to maximize the flow path (and thus settling time) from the influent pipe. Where these measures cannot provide acceptable effluent quality it may be necessary to add chemical coagulants to enhance settling.

Where feasible, a layer of low cover vegetation between the outfall and the receiving watercourse will provide some additional removal of particulate material.

By dredging the poorest quality material first and capping it with better quality material, best use will be made of a site's initial settling capacity. This practise will also minimize the need for a covering layer of clean fill to prevent biological uptake in plants and contaminant losses through surface erosion.

Consideration must be given to protecting ground water quality. Most nearshore disposals will not create significant hydraulic gradients but it may still be advisable to apply an appropriate covering layer over mobile contaminants to prevent infiltration.

Dykes will be built as narrow as possible to maximize internal capacity and minimize construction costs. It is imperative that the dykes are capable of withstanding internal hydraulic pressures, seepage, and erosion from internal and external waves. Determination of the dyke height must consider the possibility of overdredging (up to 25% is not uncommon); expansion of the dredged material vs. its in situ volume; settling of the dyke itself; sufficient freeboard to prevent overtopping by waves.

Within the confined disposal, water quality will deteriorate to a degree determined by the dredge spoil quality and the method and rate of spoil placement. At semi-confined sites, the degree of circulation with the parent waterbody will be a further factor. Water quality may become so poor as to be directly lethal to aquatic organisms. In any case, most sites are designed to become dry land, thus eliminating all aquatic organisms. Contaminant uptake during the interim period (which may exceed 10 years) poses a potential threat to birds and animals which prey on aquatic organisms within the disposal (and to fish in the case of semi-confined disposals).

Most confined disposals, especially those filled by hydraulic dredges, will have a direct discharge back to the watercourse. The discharge may be in the form of seepage through the dyke medium or overflow via an outlet structure. In the final stages of hydraulically filling a disposal, much of the settling capacity of a site has been lost and the overflow quality is poor.

Dyke failure is not uncommon, particularly on low cost projects using earth fill dykes. The sudden release of the disposal site

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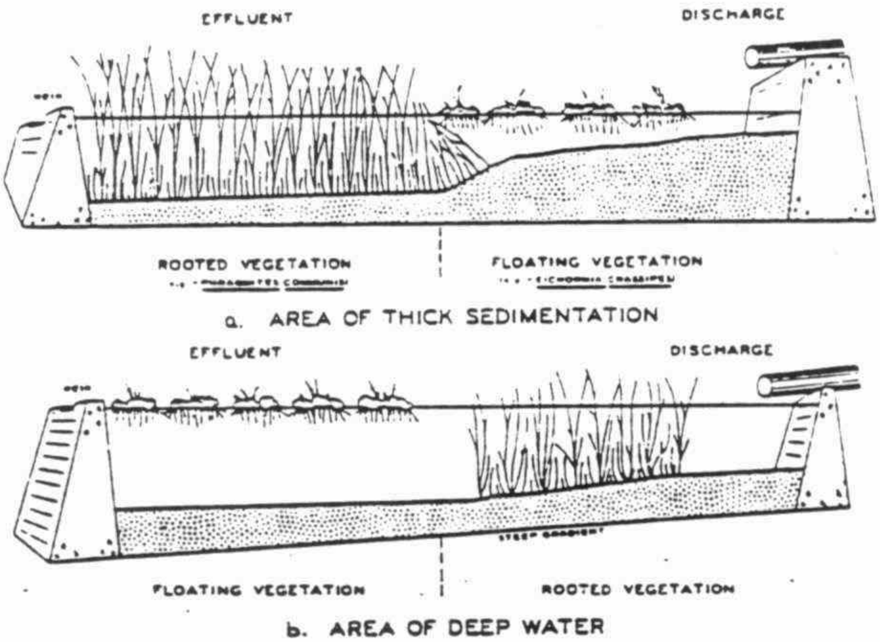
Dyke failure is not uncommon, particularly on low cost projects using earth fill dykes. The sudden release of the disposal site

contents can have serious adverse effects and must be prevented. Most of the potential structural problems associated with confined disposal areas can be mitigated through careful planning, design and the appropriate size and type of material. Each project must be assessed on a site and case specific basis.



From: Feasibility of the Funtional Use of Vegetation to Filter, Dewater and Remove Contaminants from Dredged Material. C.R. Lee, et al., U.S. Army Corps of Engineers Dredged Material Research Program. June 1976.

FIGURE 2.3.C POSSIBLE UTILIZATION OF ATTACHED AND FLOATING VEGETATION TO IMPROVE DISPOSAL EFFLUENT QUALITY

2.4 DREDGE SPOIL DISPOSAL INFORMATION REQUIREMENTS FOR REVIEWERS

- o Land Use
  - * existing land and water uses at site
  - * configuration and ultimate use of disposal
  - * scheduling of construction, operation and restoration phases
- o Physical
  - * existing onshore and offshore physiography
  - * littoral processes at site
  - * existing aquatic habitat
  - * configuration of disposal
  - * construction methodology and materials
  - * existing aquatic habitat

- o Water Quality
  - * existing water quality
  - * dredge spoil quality and quantity
  - * basin rentention times
  - * projected effluent quality

2.5 ADDITIONAL INFORMATION SOURCES

o Guidelines and Register for Evaluation of Great Lakes Dredging Projects, Report of the Dredging Subcommittee to the Great Lakes Water Quality Board, International Joint Commission, 1982.

o International Working Group on the Abatement and Control of Pollution from Dredging Activities, 1975.

o Weir Design to Maintain Effluent Quality from Dredged Material Containment Areas, Thomas M. Walski, Paul R. Schroeder, U.S. Army Corps of Engineers. Dredged Material Research Program, May 1978.

o Upland and Wetland Habitat Development with Dredged Material: Ecological Considerations, John D. Lunz, Robert J. Diaz, Richard A. Cole, U.S. Army Corps of Engineers Dredged Material Research Program, December 1978.

o Feasibility of the Functional Use of Vegetation to Filter, Dewater and Remove Contaminants from Dredged Material, C.R. Lee, R.E. Hoeppel, P.G. Hunt and C.A. Carlson, U.S. Army Corps of Engineers Dredged Material Research Program, June 1976.

o The Effectiveness of Confined Disposal Facilities for Mercury Contaminated Dredge Spoil from the St. Clair River, A Summary of Studies Between 1973 and 1981, by W.D. Wilkins & Assoc., March 1982, for Environment Canada, unpublished.

o Design Concepts for In-Water Containment Structures for Marsh Habitat Development, James W. Eckert, Michael L. Giles, Gerald M. Smith, U.S. Army Corps of Engineers, Dredged Material Research Program, July 1978.

o Sizing of Containment Areas for Dredged Material, Suzanne E. Lacasse, T. William Lambe, W. Allen Marr, Department of Civil Engineering, Massachusetts Institute of Technology, for U.S. Army Corps of Engineers Dredged Material Research Program, October 1977.

o Vegetation for the Rehabilitation of Pits and Quarries in Ontario, C.J. Heeney et al., Ontario Ministry of Natural Resources.

CHAPTER THREE
LAKEFILLS AND PIERS

3.1 DESCRIPTION

This section deals with the permanent or temporary placement of structures in a watercourse including lakefills, piers, docks, causeways, and cofferdams.

Lakefills are land masses created by dumping earth and rubble fill into a lake. The term landfill is sometimes applied to this activity but that leads to confusion with sanitary landfills. Lakefills are different from most engineered marine structures in that earth and rubble are often left exposed to wave action with only minimal conventional shore protection. In most cases, the designers attempt to create "stable" beaches and place armour stone only at hardpoints at the ends of the beaches.

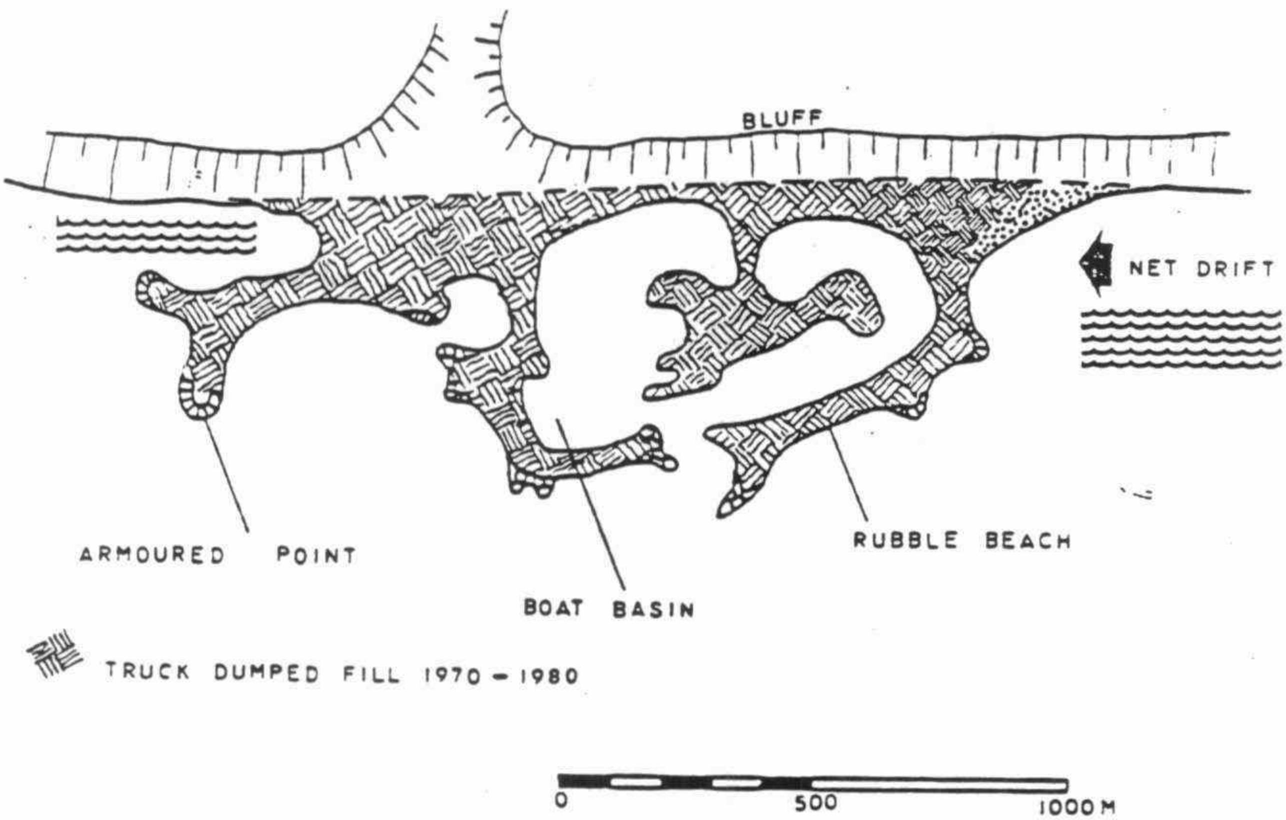


FIGURE 3.1.A SCARBOROUGH BLUFFS LAKEFILL

Piers and docks are structures built to provide berthing space for ships. While they may incorporate fill, at least part of the structure will have a vertical face at which ships can tie up to load and/or unload cargo. Cargo handling equipment such as cranes, hoppers, conveyors or pipelines are often provided. Piers may be extended well out from shore to shipping depths (about 9m for full size Great Lakes vessels) to minimize dredging requirements. The availability of local materials, the commodity to be transferred and site constraints will determine the method of pier construction. The Stelco pier at Nanticoke shown below in Fig. 3.1.B incorporated a bridge, a causeway, and concrete crib segments.

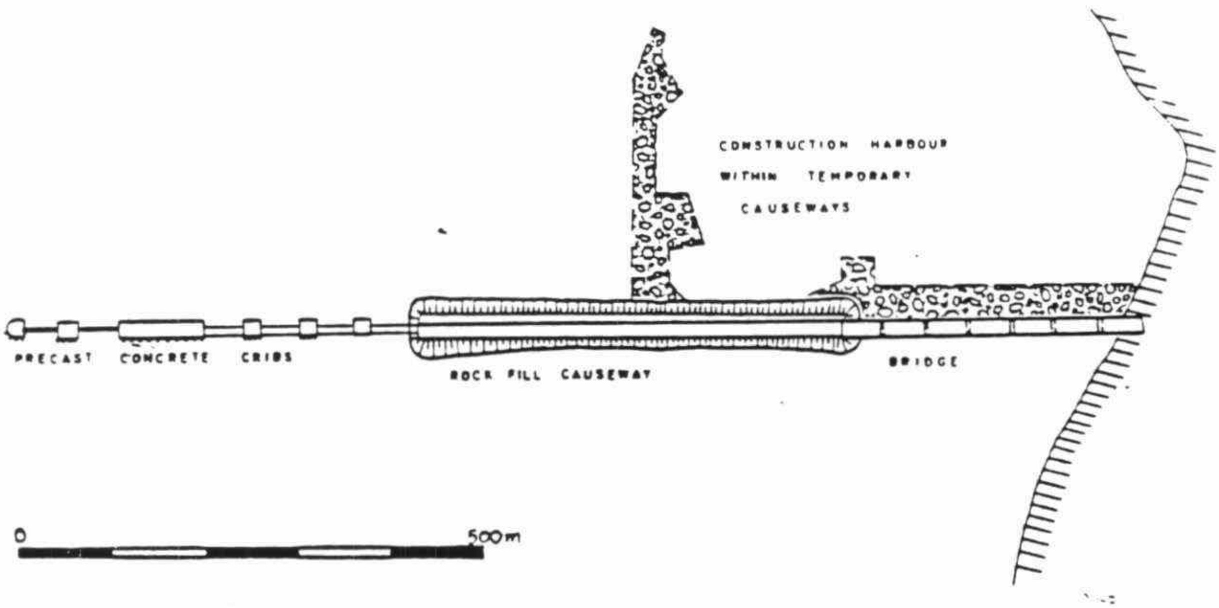


FIGURE 3.1.B STELCO PIER

Causeways are berms or raised roadways connecting two land masses or an offshore structure to the shore. Causeways are called for where water depths and the supply of fill material make them more attractive than bridges.

Cofferdams are temporary barriers built to allow the dewatering of an area of lake bottom usually for construction in the dry of another structure. Cofferdams range from simple earth berms to elaborate interconnected cells of steel sheet piling.

3.2 LAKEFILLS AND PIER IMPACTS

a) Lakefills

Many of the same impacts associated with shoreline dredge spoil disposal facilities described in Chapter 2 are common to lakefills. They represent a permanent change from aquatic habitat to terrestrial habitat. The site usually affects a change from a natural shoreline to an artificial one which may have high maintenance requirements.

Over the last ten years the construction of lakefills for recreational use has become common around the heavily developed shoreline of western Lake Ontario. Each lakefill incorporates a basin to provide a small craft harbour while the remainder of the site is open land for passive use. Water quality in the basins thus created can be significantly worse than in the adjacent lake. This may be due to a waste discharge, including storm sewers, located within or nearby the lakefill. Poor quality water thus results from occasional discharges of the sewers as effluents are trapped within the basins rather than dispersing into the open lake.

The filling activity itself has an adverse impact (increased turbidity and suspended solids) on water quality due to the loss of fill. Currently active lakefill sites accept earth and rubble fill from private and public sector construction projects. Visual site supervision alone cannot be expected to maintain adequate control over the quality of the fill. Excavations for roads, railroads, sewers and redevelopment of industrial sites all have the potential to generate contaminated fill.

The magnitude of fill losses to the water column varies from site to site and by season. Sites which continue dumping earth fill in stormy weather or do not have sufficient rubble to protect the earth fill are subject to substantial losses.

Sediment quality is affected as eroded fill settles to the bottom. Fluid mud in the bottom waters move downslope from the dump face as a density current and disperse offshore. The exposed face of most lakefill sites is a non-depositional zone for fine grain size particulates but some accumulation may develop in calm periods. Embayments and enclosed boat basins will offer a depositional environment and will accumulate mud deposits. The chemical quality of the mud reflects the quality of the fill and the quality of nearby sewer discharges.

The impact on littoral zone habitat can be substantial. A given site may extend several kilometers offshore to water depths of 15m and directly bury many hectares of lake bottom. The lakefill may alter nearshore current patterns such that dispersion of wastes from existing outfalls is offered.

Lakefills built on shorelines subject to littoral transport typically block that transport. The accumulation of material on the updrift side may interfere with intakes, outfalls and aquatic habitats. Erosion on the downdrift side may necessitate remedial measures.

b) Piers

Few of the water quality problems associated with lakefills occur with piers or docks. In the latter case earth fill, if used at all, is promptly protected from erosion. Construction periods are comparatively short, seldom extending beyond one year. Since the main function of the pier is to facilitate the transfer of cargo from ships to shore, it is not necessary to create a land mass in the watercourse. Indeed it may be feasible to build the pier on pilings. Where the pier is a solid structure, the considerations of impact on littoral transport and direct loss of aquatic habitat apply.

c) Causeways

Causeways may be built of earth or rock fill. The water quality impacts during construction will depend on the nature of the fill, the severity of exposure to wave attack and the duration of construction. The post-construction impacts may be significant sie causeways are most often used to make connections between mainland and islands or structures in shallow, biologically productive environments. By its nature, causeway construction restricts water movement and that can create water quality impairment and loss of aquatic habitat.

d) Cofferdams

Cofferdams built of earth fill are subject to the same water quality problems as lakefills, although over a much shorter time period. Rock-fill cofferdams will probably require some earth fill to provide a seal which will allow dewatering. Placement of the cofferdams may have to be staged to allow streamflow for other water users (including migratory fish). Water pumped out of the cofferdam may have to be directed to a settling basin or otherwise restricted if it has become highly turbid or contaminated from excavation work within the cofferdam. Closing off an area with a cofferdam may trap a resident fish population. Water quality impacts of cofferdam removal will be comparable to those for initial construction. While the cofferdam is in place sediment generated by construction activities may accumulate around it.

3.3 IMPACT MITIGATION MEASURES

a) Lakefills

Siting of a lakefill is critically important. Long term land and water use need to be carefully considered to ensure compatibility with the proposed structure and its likely uses. In developed areas it is important to assess the impact of a lakefill on ongoing or planned water management programs. For example, continued dumping of earth fill is incompatible with measures to control shoreline and upstream sources of sediment loadings to the Great Lakes. Recreational water use at some lakefills can actually be impaired by construction of the facility designed to enhance it. Impaired dispersion of nearby effluents, discharges of storm water from the site, and turbidity from erosion may restrict swimming and board sailing and even make small craft boating less desireable.

Water quality within the enclosed boat basins will be discussed at greater length in Chapter 4: Marinas. Circulation between the basin and the lake should be kept as high as possible while providing a safe haven for boats. Direct discharges to the basin should be avoided. Embayments which may be created to either side of a lakefill will usually have poorer water quality than that of the open lake. Avoiding discharges to these areas will help maintain water quality. The lakefill should be located such that existing outfalls will not deter from the desired uses of the proposed embayment.

Considerable effort will be required to ensure that earth and rubble fill delivered to a lakefill site are reasonably free of contaminants. When fill is dumped directly into a watercourse the potential impact of contaminated fill can be quite serious and the remedial measures are very limited and expensive. Once a source of clean fill is obtained, then that fill should be utilized without significant loss to the water column. PLUARG (1978) recognized sediment per se as a contaminant and has recommended steps to reduce all inputs.

There should always be an available supply of coarse material to protect the active earth fill face. The coarse material may be broken concrete and brick rubble or purchased stone. The protective layer should be sufficiently thick to protect the earth fill from erosion. The rubble should itself be sufficiently free of fines and contaminants as to not cause water quality degradation.

Lakefilling techniques were developed by the Toronto Harbour Commission in the 1950's and refined during the 1970's to minimize environmental impacts. The Harbour Commission indicates that the following four rules are to be met to achieve relatively stable beach slopes subject only to slow attrition losses caused by abrasion and weathering:

1. An anchor (hardpoint) at each end of a beach to prevent the longshore escape of beach material.

2. The enclosed beach should describe an arc of a circle of about 15°.

3. The beach slope material size must be compatible with the gradient -- the larger the material the steeper the allowable slope.

To minimize fill losses from this type of lakefill project, it is desirable to construct the hardpoints as soon as possible. The beaches will likely require years of feeding with the correct size of material to achieve stable slopes and routine maintenance as materials are eroded.

Fill losses (and thus contaminant loss and turbidity levels) are more effectively controlled by placing earth fill behind a protective rubble berm. The disadvantage is that as water depth increases, the amount of rubble required to build the berm becomes significantly greater than the amount required to cover an existing slope. Where there is an ample supply of rubble material, this option is the more desirable.

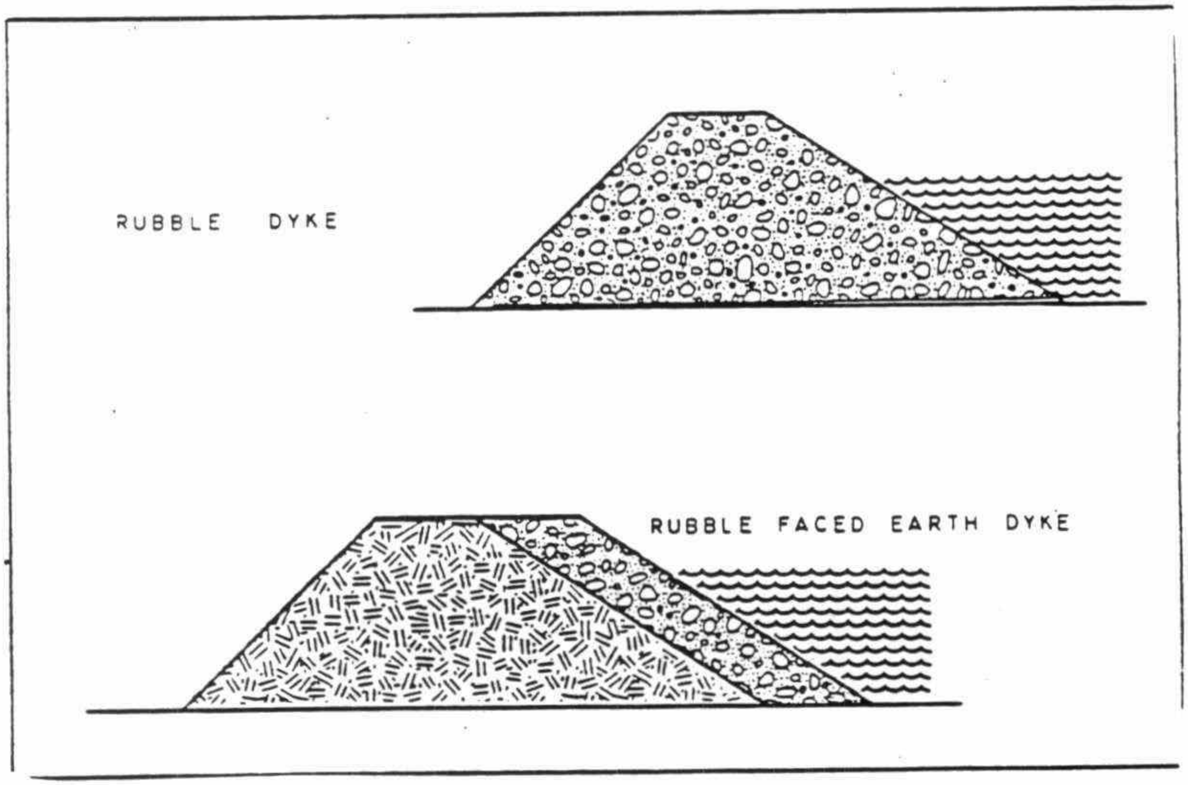


FIGURE 3.3.A RUBBLE vs RUBBLE FACED DYKES

Floating rubber tire breakwaters may have some application in reducing wave exposure at a fill face. In "quiescent" conditions silt curtains can be used to control the dispersion of turbid water. Silt curtains may not be effective in areas with significant water movement generated by waves, currents or river flows.

b) Piers

At a dock or pier littoral transport problems can be minimized by making the structure sufficiently open. The pier can incorporate a bridge section near shore, be raised on piles or be built of cribs interconnected above water. The same remedies avoid interference with existing waste discharges or fish migration patterns.

c) Causeways

Use of earth fill to construct a causeway will cause some of the direct water quality impacts attributed to lakefills. These are minimized by providing slope protection to prevent erosion. Culverts or bridge segments can be used to allow water movement and fish passage through a causeway. Unless there is a defined channel where flow is concentrated, the degree of circulation afforded by these measures will be considerably less than existed previously.

d) Cofferdams

Earth fill cofferdams should only be employed where the earth is not subject to erosion. Earth fill is not appropriate, for example, in a fast flowing stream. The design of a cofferdam used to cut off flow in a stream without significantly raising turbidity levels is shown in Figure 3.3.B.

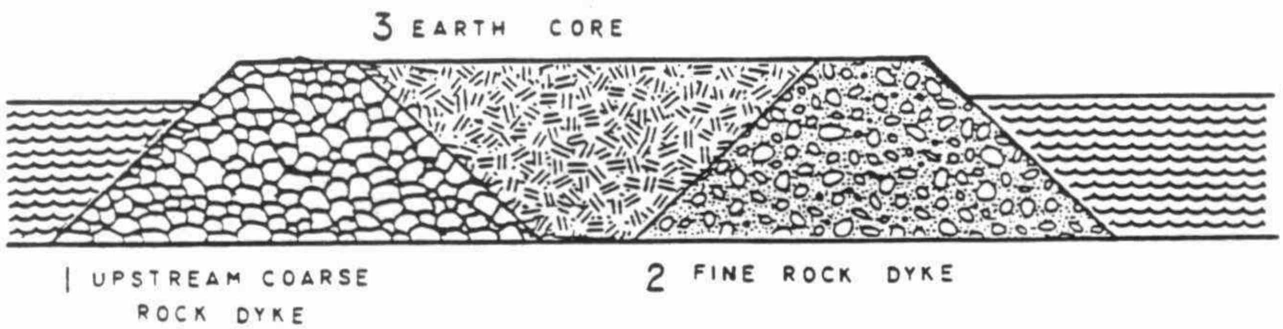


FIGURE 3.3.B INSTREAM COFFERDAM

Where excavation is to take place within a cofferdam it is desirable to dewater the area as much as possible first to avoid excessive turbidity in the water and to allow dry handling of the spoils. If fish have been trapped within the cofferdam, they can be rescued by seine netting at low water levels and transferred back to open water.

During removal of a cofferdam, the earth seal or core should be removed first rather than at the same time as the rock fill. If sediment has accumulated against the cofferdam it may be necessary to remove it prior to removing the cofferdam to avoid a slug of sediment being washed downstream when normal flow conditions are restored.

Steel sheet pile cofferdams have negligible direct water quality impacts and their use may be applicable in sensitive aquatic habitats, high stream flow conditions or restricted areas where an earth and rock berm would require too much space.

3.4 LAKEFILL AND PIER INFORMATION REQUIREMENTS FOR REVIEWERS

- Existing topography onshore and offshore.
- Site geomorphology.
- Wind and wave climate.
- Lake levels with variations due to season, storm set-up and year to year for past 20 years.
- Historical erosion rates at site.
- Littoral transport characteristics.
- Project layout.
- Source and quality of fill.
- Construction procedures and sequence.
- Shore protection design.
- Water uses especially intakes and outfalls in area.
- Aquatic habitat characteristics.
- Existing water quality.
- Existing sediment quality.
- Predicated water quality especially in new embayments.
- Predicted sediment quality.
- Maintenance requirements.

3.5 LAKEFILL AND PIER SUPPLEMENTARY INFORMATION

- Recreational Landfills and the Lake Ontario Environment, J.J. Collins and R.S. Boulden, Environment Canada, M.S. Report No. O.R.-14, May 1978.

- Lakefill Quality Study, Leslie Street Spit, City of Toronto, Environment Canada and Ontario Ministry of Environment, August 1982.

- A Summary Report on the Effects of Dredging, Dredged Spoils Disposal and Lakefilling Activities on Water Quality in the Toronto Waterfront, August 15 - November 29, 1980, M. Griffiths and J. Winiecki, Ontario Ministry of Environment, November 1981.

- Completion of the East Headland and Endikement, Engineering Department, Toronto Harbour Commissioners, December 1982.

- Great Lakes Fill of Non-Aquatic Origin: Appendix 6 in Guidelines and Register for Evaluation of Great Lakes Dredging Projects, Report to the Great Lakes Water Quality Board, International Joint Commission, January 1982.

- Big Chute Fish Rescue, A.R. Emery, M.A. Townes, Ontario Fish & Wildlife Review, Vol. 17, No. 2, 1978.

CHAPTER FOUR
HARBOURS AND MARINAS

4.1 DESCRIPTION

A harbour, whether a natural area of refuge, a commercial port, or a recreational marina, by definition is a water area partially enclosed and so protected from storms as to provide safe and suitable accomodation for vessels. Natural harbours may exist at embayments (Hamilton) in the lee of the islands (Toronto), or at river mouths (Whitby, Oshawa, Grand Bend). Artificial harbours may be developed by constructing offshore breakwaters (Port Credit, Thornbury), or by excavating basins behind the original shoreline (Fifty Point, Lagoon City). Typically in Ontario, natural harbours have been artificially enlarged by the construction of breakwaters and by dredging to accomodate the increase in size of commercial vessels or the increase in the number of pleasure boats. More recently, as natural sites have been fully developed (particularly in western Lake Ontario), completely artificial harbours are being constructed in areas which were previously exposed open shoreline (Bluffers Park, Fifty Point).

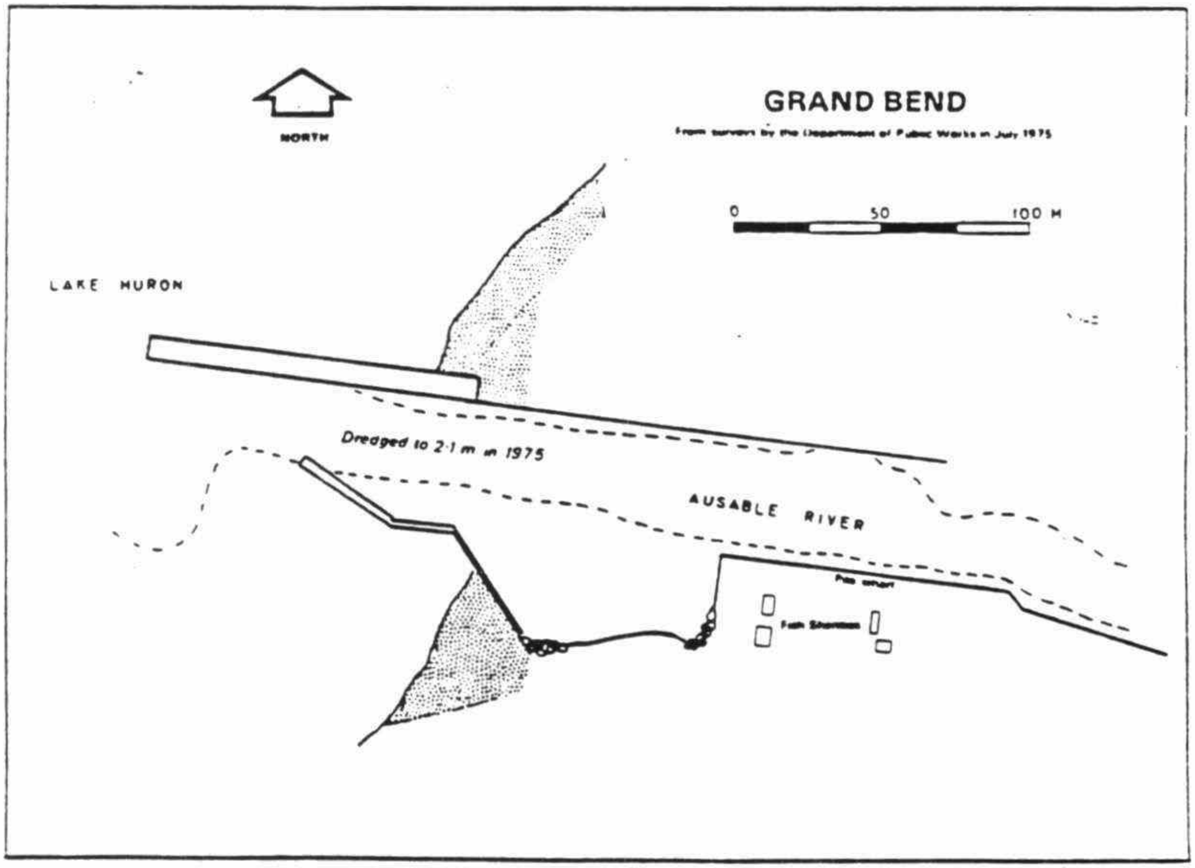


FIGURE 4.1.A GRAND BEND HARBOUR

Grand Bend is a river mouth harbour suffering drawbacks typical of its type. It requires routine maintenance dredging, offers limited mooring space and is physiographically constrained from expanding. Its entrance jetties also adversely affect littoral drift.

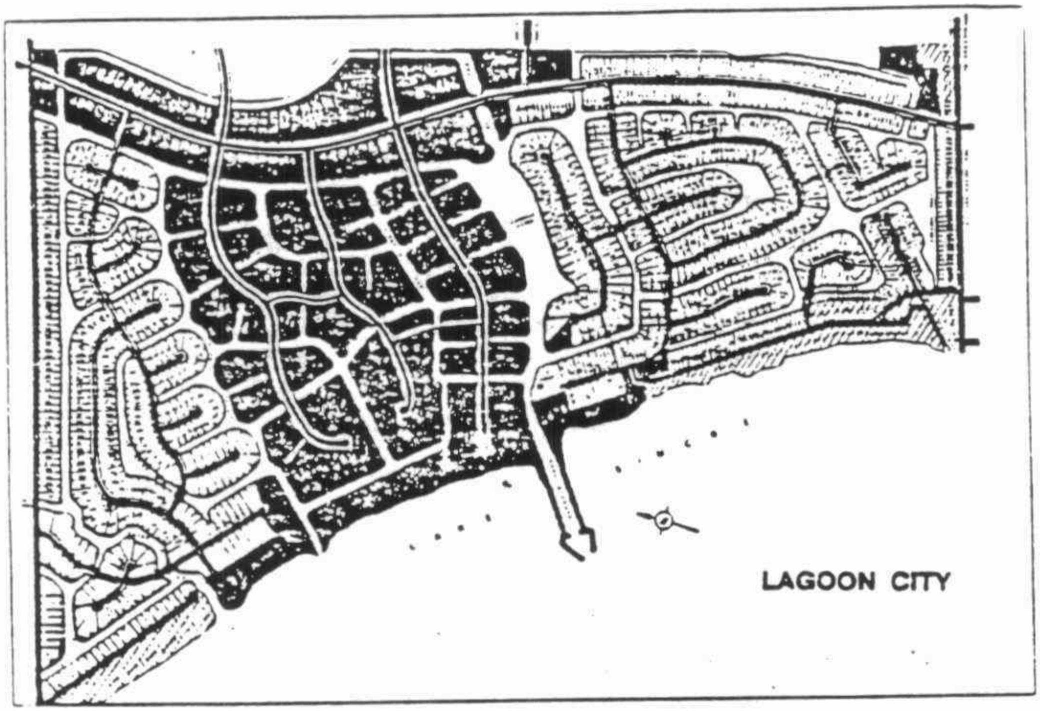


FIGURE 4.1.B

Lagoon City is a recreational community on Lake Simcoe incorporating a harbour and a network of channels dredged from boggy land.

New commercial ports as such are unlikely to be developed beyond the existing ports on the Ontario Great Lakes shoreline. The nature of the cargoes (bulk commodities) and the design of modern self-unloading vessels is such that shipping requirements can be met by the construction of relatively simple piers. More common construction requirements for commercial shipping are maintenance work (especially dredging) and port adjustments to accomodate new trends in shipping. The move to containerization of goods has decreased the need for large numbers of wharves and wharf-side warehousing and increased the need for open space. Fewer industries are moving their goods by water and requiring waterfront locations. Most of the tonnage moved on the Great Lakes is now in the bulk commodities coal, grain and iron ore.

In contrast to commercial shipping, recreational boating continues to incease. Marina proposals are now often included as a focal point in waterfront housing and recreation complexes. Particularly on the Great Lakes there has been a shift to sailboats from

powerboats. Much of the growth in boating has been in sailboats over twenty feet in length which are kept moored at marinas.

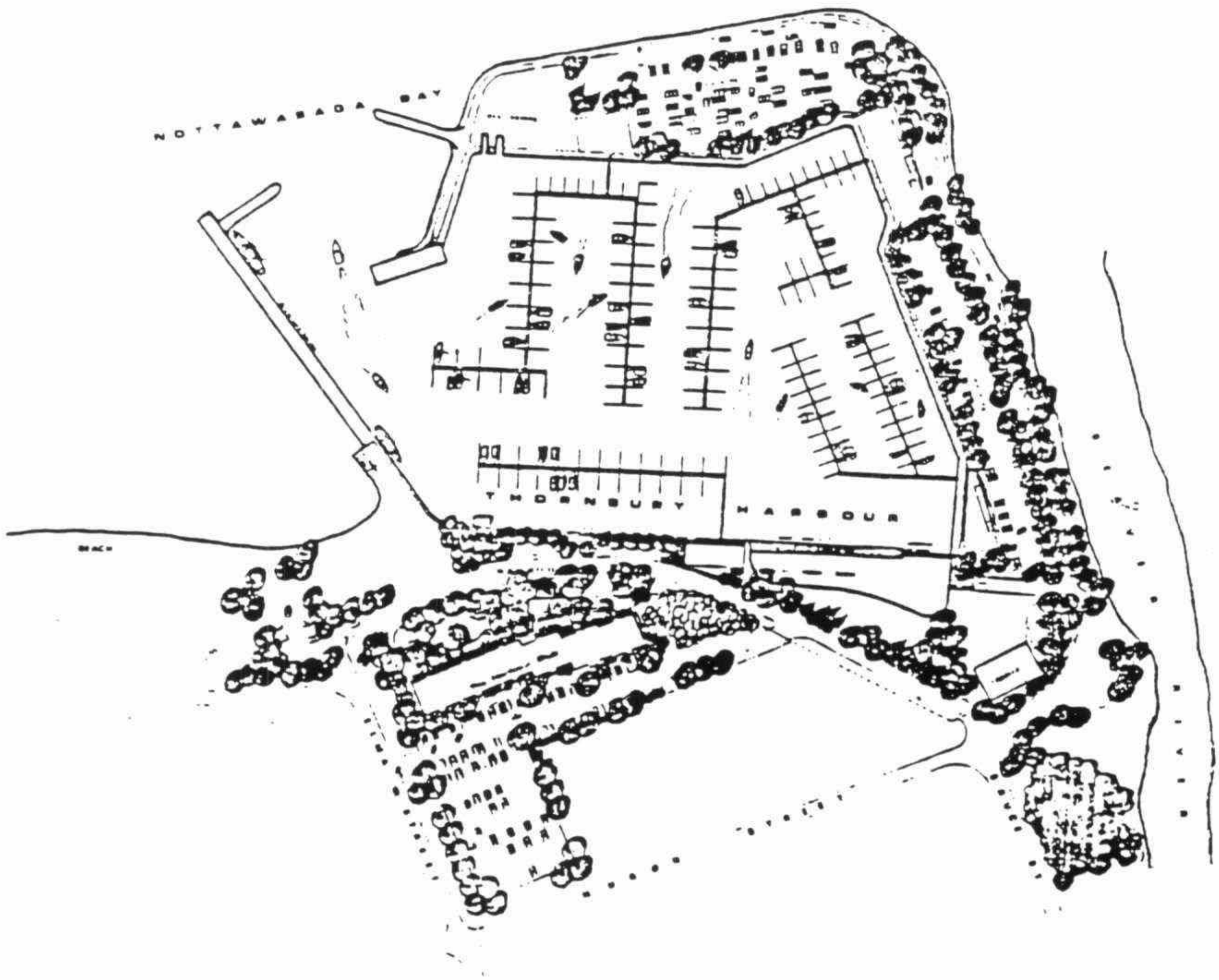


FIGURE 4.1.C THORNBURY HARBOUR

Thornbury Harbour is an example of disused commercial facilities now extensively upgraded for pleasure boat use. The harbour is sheltered by offshore breakwaters now connected by a neck of land to the mainland. The Beaver River enters Georgian Bay adjacent to rather than via the harbour.

Water quality in the nearshore zone of most lakes is somewhat poorer than offshore as a result of tributary and direct discharges and eroding shorelines. Lake circulation is an important factor in maintaining water quality.

4.2 HARBOUR CONSTRUCTION ACTIVITIES

This section applies to both commercial port expansion and marina construction. A major difference is the added emphasis at the marina on maintaining water quality to enhance the recreational experience.

a) Siting Considerations

Compatible land uses. Commercial port facilities require land transportation service and may need buffering from other uses. Marinas may be incompatible with natural areas or heavily industrialized areas.

Compatible water uses. Avoid conflicts with water supply and waste disposal. Harbour development in river mouths may conflict with flood control. Recreational boating may interfere with use of bathing areas or with commercial vessel traffic.

Water movement. Circulation in slips or marina basins will be necessary to prevent water quality deterioration. This can be difficult to achieve since harbours must minimize wind driven waves and currents to shelter boats. Circulation is easiest to achieve where multiple openings to the boat basin can be provided to take advantage of prevailing currents.

Coastal processes. A thorough understanding of coastal processes and stream sedimentation patterns at the site is necessary to produce a design with minimum long term maintenance requirements. When that option does not exist, long term disposal capacity for contaminated dredge spoil should be designed into the project.

b) Dredging

Dredging is the most common component of harbour construction. MOE has prepared a separate set of guidelines on this activity and it will not be discussed here at length. Where possible it is preferrable to excavate spoils in the dry and dispose of them on land. Sediment quality should be established to determine the appropriate disposal methodology. Contaminated sediments are not to be dumped in open water.

c) Filling

Filling operations typically accompany dredging in the creation of harbours. An area of open flat land as large as the water area will be required for commodity storage, parking, winter boat storage etc. This land area is most often obtained by filling in wetlands or nearshore shallow water. Filling has been discussed at length in Chapter 3.

d) Shoreline Treatment

Most harbour facilities will require some areas of vertical bulkheaded walls for berthing. Such walls should be designed to maintain the integrity of the backfill by using the equivalent of interlocking sheet piles or by placing filter fabric against the inside of the wall.

Where space permits, energy expending beaches inside a basin will decrease reflected waves. Such beaches should be sufficiently coarse to maintain their slope without extensive maintenance. All earth banks should receive some protection to prevent erosion and subsequent water quality deterioration. In some instances appropriate planting may suffice.

Sloping revetments will generally be cheaper to install than vertical bulkheads and offer the advantage of providing habitat to aquatic organisms. This will be a disbenefit and create maintenance problems in those areas subject to excessive growths of attached algae.

e) Site Services

It should be appreciated that many boat owners will spend most of their "boating" time at the marina dock socializing as though the boat were a cottage. Accordingly the need for onshore facilities will be considerable. Washrooms (perhaps one per 20 boats) and showers will often be supplemented with a laundromat, supplies store, clubhouse and restaurant. Demand for sewage facilities may be as great as in a cottage subdivision.

Probably every marina will offer fuel sales. The fuel dock should be designed to minimize the impact of potential spills while complying with safety requirements related to fire and explosions.

Waste holding tank pumpout facilities should be provided which subsequently discharge to approved onshore facilities.

Every effort should be made to prevent the direct discharge of contaminants to the boat basin. Seepage from septic tanks or even surface runoff from parking lots and work areas can degrade water quality in a boat basin with limited water circulation.

At commercial docks cargo handling facilities become important, especially for bulk commodities. Provisions to prevent spillage, control dust and collect surface runoff will be necessary to protect water quality. For some classes of vessels it will be necessary to provide onshore treatment facilties for the discharge of contaminated ballast and bilge water.

4.3 MITIGATION OF HARBOUR CONSTRUCTION IMPACTS

a) General Considerations

Protection of remaining adjacent wetlands must be carefully assessed during a harbour construction. These biologically productive areas have an important role to play in efforts to rehabilitate aquatic habitat, especially in the lower Great Lakes. Some success has recently been achieved in creating new wetlands however, little long term data are available on their performance compared to mature natural marshes. A reviewer is cautioned against accepting the destruction of existing marshland in exchange for the artificial construction of another. Additionally, the littoral zone habitat is under considerable stress from competing water uses and efforts should be made to minimize additional stresses. Construction in the littoral zone may offer the opportunity to upgrade the quality of the habitat by providing artificial spawning shoals and reef refuges.

Provision of adequate circulation will dominate water quality considerations in a new harbour or marina basin. The American Society of Civil Engineers recommends a the preferred flushing rate of 2 times daily. In the Great Lakes non-tidal situation, this will often be difficult to achieve. The U.S. Corps of Engineers suggests that for single-entrance harbours, an average daily exchange of water equivalent to one third of the harbour volume will be sufficient to prevent stagnation. They further recommend that where water level fluctuations are small, two entrances designed to catch wind generated currents such that a complete exchange of water occurs every ten days, will usually be adequate.

Major harbour construction on the exposed shoreline of the Great Lakes often merits evaluation in an hydraulic model. Water quality considerations should be examined along with the coastal engineering aspects. Some mathematical models are available to examine water exchange and predict water quality.

In situations where no natural means of circulation is available to overcome foreseen water quality problems, flows may be artificially induced by pumping.

Any harbour structure is likely to have some impact on coastal processes, requiring mitigation. The most common impact is the interruption of littoral drift by the construction of breakwaters or entrance jetties across the littoral zone. Unless the structure can be located at a nodal point where there is no net drift (or on a rocky shoreline where there is none at all) it will be necessary to bypass sand from the updrift accumulation area to the downdrift erosional area.

Littoral drift characteristics must be balanced against safe entrance considerations in designing a harbour mouth that is not prone to shoaling.

New facilities located on the busy shores of the Great Lakes are likely to be impacted to some degree by existing water users. Municipal and industrial discharge plumes may limit recreational water use. Careful evaluation of existing water quality conditions are adviseable.

b) Dredging

Impact mitigation measures are discussed in greater detail in the dredging guidelines (Evaluating Construction Activities Impacting on Water Resources - Part III - Guidelines for Dredging and Dredged Material Disposal). A few principles are dicussed below.

Where wet excavation in silt and clay is necessary, mechanical dredges (backhoes, clamshells and to a lesser degree draglines) are preferable to hydraulic. The latter maximizes soil contact with the water, creating more turbidity and increasing adverse impacts of contaminants associated with the sediments. With hydraulic dredging of fine grained sediment, one or more settling ponds will be needed to obtain an effluent of acceptable quality for release back to the watercourse. Keeping the spoils as dry as possible (especially by excavating in the dry), improves the load carrying capacity and workability of the spoil which facilitates beneficial uses around the site.

c) Filling

Construction should be scheduled such that perimeter bulkheads and revetments are built first to retain fill.

Grading surfaces away from the waters edge to settling ponds, catch basins and ditches will minimize siltation in the harbour.

Contaminated fill should be kept away from the harbour by impervious berms or membranes.

d) Shoreline treatment

From an environmental standpoint, the best shoreline treatment will be one that gives long term protection against erosion, is itself inert, and requires little maintenance. Numerous materials meet those requirements and selection will depend on site and cost considerations. For vertical walls, steel sheet piling and soldier piles with precast concrete panels have proven effective. On sloping revetments, appropriately sized local stone is all that may be required.

e) Site services

The most important mitigative measures in this category are steps to prevent access of contaminants to the water.

Sanitary sewage should be directed to a municipal system or extra precautions taken in the design of an on site system.

Storm drainage should be directed away from a confined basin. If it must discharge to the basin, it should do so through regularly maintained catch basins rather than overland flow. Consider that the parking lots will probably also be used for winter storage of boats and a component of that is annual replacement of bottom antifouling paint. Antifouling compounds can affect water quality if allowed to enter a water course.

Heat and nutrient inputs to the basin should be avoided to minimize algal growths. Regularly emptied waste receptacles will be required throughout the marina. Marina users (and especially an on-site repair facility) generate significant quantities of waste paint, solvents, cleaning compounds, wood preservatives, used oil, etc., that must be kept away from the water.

A launch ramp will require a hard bottom to prevent erosion. It should be located in an area of good circulation since it generates unavoidable inputs to the water. If provisions are made for washing off hauled boats that runoff should be directed to the storm water system away from the basin.

Finally, an effective landscaping treatment will do much to enhance environmental quality. Planting can be designed to reduce wind, dust, noise and erosion. A secondary benefit is an attitude engendered in users which encourages good housekeeping habits.

4.4 INFORMATION REQUIREMENTS FOR REVIEWERS

- o Existing Site Characteristics
  - * land use
  - * physical site topography onshore and offshore
  - * terrestrial habitat
  - * aquatic habitat
  - * water quality
- o Proposed Development
  - * layout
  - * anticipated habitat changes, terresrial and aquatic
  - * anticipated water quality changes
  - * operational characteristics
- o Construction
  - * scheduling
  - * proposed methodology
  - * mitigation measures

4.5 SUPPLEMENTARY INFORMATION

- o Small Craft Harbours: Design Construction and Operation, James W. Dunham and A.A. Finn, U.S. Army Corps of Engineers, Coastal Engineering Research Center, 1974.

- Marinas: A Working Guide to their Development and Design, Donald W. Adie, 1977.

- Design and Construction of Ports and Marine Structures, Alonzo D. Quinn, 1972.

- Report on Small Craft Harbours, Task Committee on Small Craft Harbours, American Society of Civil Engineers, George T. Treadwell, Chairman, 1969.

- Flushing Study of South Beach Marina, Oregon, Richard J. Callaway in the Journal of Waterway, Port, Coastal and Ocean Division, Proceedings of the American Society of Civil Engineers, Vol. 107, No. WW2, May 1981.

- Design and Construction Manual for Floating Tire Breakwaters, Craig T. Bishop, National Water Research Institute, Canada Department of the Environment, July 1980.

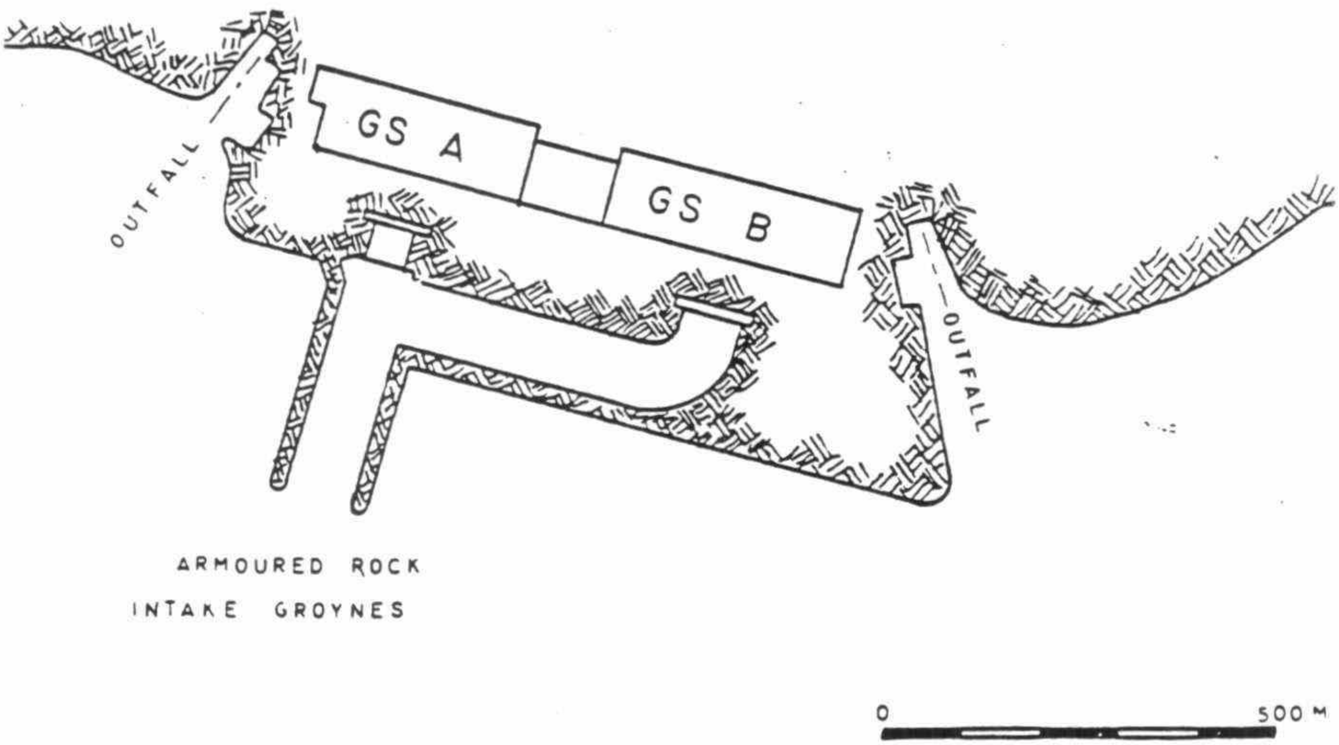
- Evaluating Construction Activities Impacting on Water Resources - Part III - Guidelines for Dredging and Dredged Material Disposal. MOE 1985.

- Ontario Ports Study: prepared by Peat, Marwick and Partners for Canada Department of Transport and Ontario Ministry of Transportation and Communications. July 1984.

CHAPTER FIVE
WATER INTAKES

5.1 DESCRIPTION

Water intakes are built in the Great Lakes to provide a steady supply of municipal potable water, industrial process water and cooling water. Offshore intakes range in size from a small diameter unburied line terminating in a simple crib inlet to a 7m diameter tunnel under the lake bottom terminating in a 50m diameter intake cap. Offshore intakes are used to avoid poorer nearshore water quality and to obtain sufficient depth to avoid frazil ice problems. Shoreline intakes are usually used when water volume requirements are high and quality requirements not stringent (especially for cooling water). Fossil and nuclear fuelled thermal generating stations have by far the greatest water requirements of all water users. Pickering Nuclear Generating Station A can draw as much as 114m3/second.



From: Report on Water Turbidity at Pickering Generating Station, Hydraulics Investigations Section, Ontario Hydro, April 1974

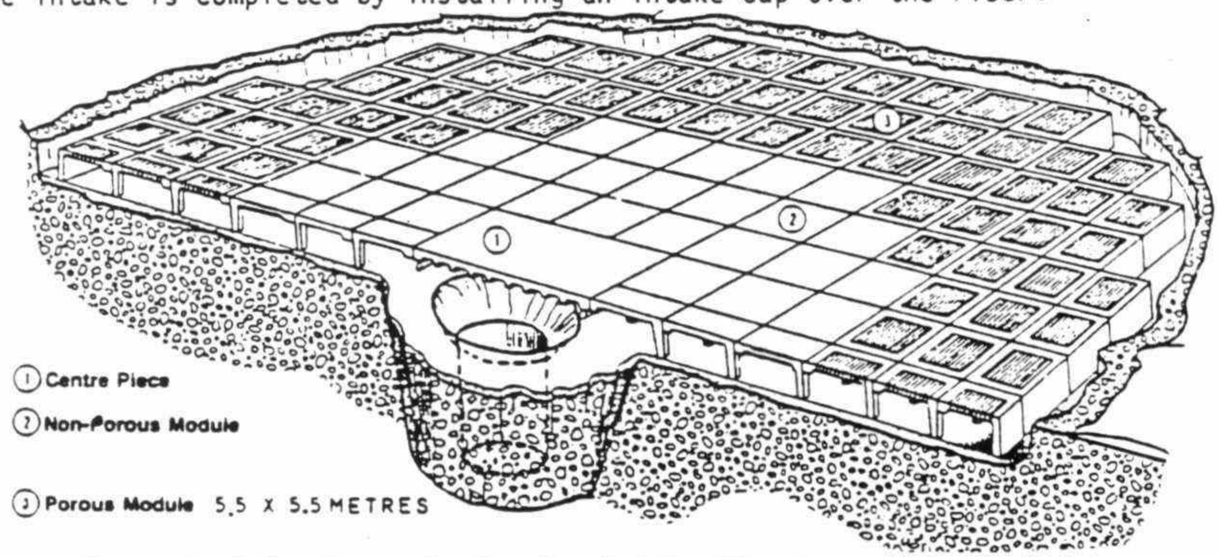
FIGURE 5.1 PICKERING NUCLEAR GENERATING STATION INTAKE (ONTARIO HYDRO)

5.2 WATER INTAKE IMPACTS AND MITIGATION MEASURES

Construction of unburied water intake pipes has minimal water quality impact. Usually there will be some kind of inlet crib or bellmouth to keep the inlet off the bottom. The inlet should be screened to prevent entrainment of debris and fish. Excavation may be necessary at the shoreline to effect the transition from offshore to onshore. The trench should be promptly backfilled to its original contours and protected from erosion. Surplus excavated material should be disposed of onshore such that it does not erode into the water.

Intakes laid in a trench will have impacts related to the scale of the dredging operation to create the trench. Unless the surficial sediments are contaminated and require special handling, the trench excavations will be placed to one side and re-used as backfill to cover the pipe. Contractors should be encouraged to carry out this operation underwater rather than bringing the material to the surface and then dropping it back through the water column. Trench material may have to be supplemented with coarser backfill in nearshore areas subject to scour. Where rock backfill is to be used over the pipe the potential exists to create desirable fish habitat.

The availability of mechanical tunneling "moles" has made it attractive to construct large diameter intakes by tunneling under the lake bed from shore. In this instance all of the excavated material is disposed of ashore except for the riser up through the lake bed. Drilling and blasting will likely be necessary to complete the riser. The intake is completed by installing an intake cap over the riser.



From: Conceptual Development of a New Intake Structure, Ontario Hydro Report No. 82434, December 1982

FIGURE 5.2 PRECAST POROUS BOTTOM INTAKE SCHEME FOR DARLINGTON G.S. (ONTARIO HYDRO)

All intakes have the potential to entrain fish, particularly larval fish. The intake should be located away from fish spawning areas and designed to avoid entrainment. At plants with warm water outfalls that attract fish, it is especially important to keep the intake from drawing in resident fish populations.

Some intakes (like Pickering G.S.) use groynes or jetties to extend beyond the nearshore zone. Those groynes can impact the littoral zone in the same manner as groynes built for shore protection as described in Chapter 1.

Dredging and blasting activities should be scheduled to minimize impacts on resident and migratory fish species.

5.3 WATER INTAKE INFORMATION REQUIREMENTS

- o Site physiography onshore and offshore.
- o Site geology including surficial sediment physical and chemical characteristics.
- o Intake design.
- o Construction methodology
  - * trenched, tunneled or surface
  - * drilling and blasting
  - * disposal of trench excavations
  - * backfill material.
- o Construction scheduling.
- o Other water uses including fish habitat.
- o Quantity of water withdrawal (withdrawals of 10,000 gal/day and over require a Ministry of Environment permit).

5.4 WATER INTAKE SUPPLEMENTARY INFORMATION

- o Report on Water Turbidity at Pickering Generating Station, Hydraulic Investigations Section, Ontario Hydro, April 1974.

- o Preliminary Engineering Report on Easterly Filtration Plant Intake and Treatment Plant Outfall at Highland Creek, Gibb, Albery, Pullerits and Dickson for the Municipality of Metropolitan Toronto Works Department, October 1971.

- o Underwater Investigation of the Pickering Water Intake, Young-Soderholm Marine Contractors Ltd. for the Regional Municipality of Durham, February 1980.

- o Marine Pipeline Installation with 'Sclairpipe', Dupont of Canada Ltd., Pipe Division, June 1974.

- o Conceptual Development of a New Intake Structure, Ontario Hydro Report No. 82434, December 1982.

CHAPTER SIX
WASTEWATER OUTFALLS

6.1 DESCRIPTION

Wastewater outfalls are built to direct stormwater, sanitary waste, industrial waste and cooling water into a watercourse for dispersion and dilution. For weak waste streams, a shoreline outfall may be all that is required to meet the Provincial water quality objectives. Most sewage treatment plants and many industrial waste streams require a submerged offshore discharge to achieve adequate dispersion and dilution. The outfall may employ a multi-port diffuser to enhance initial mixing.

Offshore outfalls are constructed by laying a pipe on the bottom or in a prepared trench or by tunnelling out from shore.

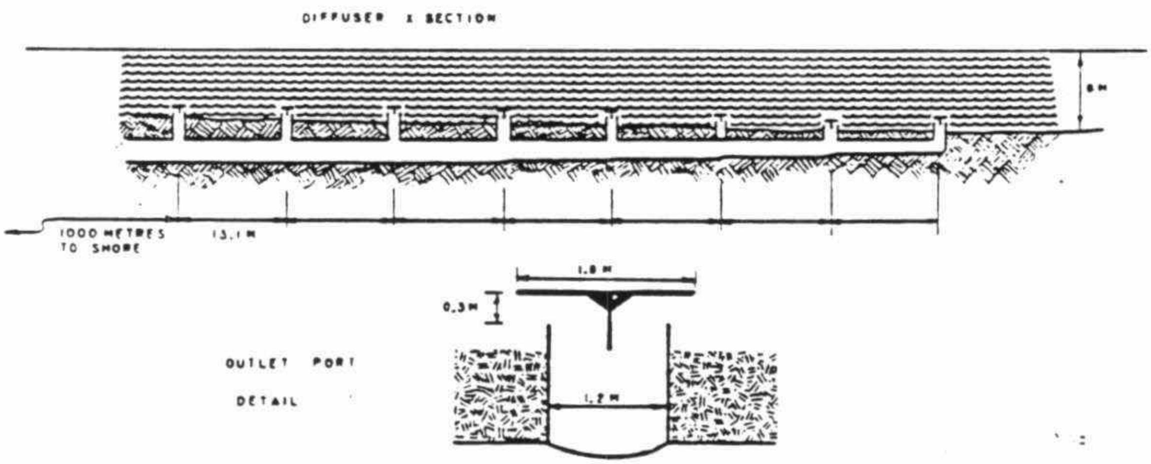


FIGURE 6.1 ASHBRIDGES BAY STP OUTFALL

6.2 WASTEWATER OUTFALL IMPACTS AND MITIGATION MEASURES

Outfall construction shares the same techniques and impacts as intake construction described in Chapter 5. The impact of construction is probably less than from its operation whereas, for intakes, the reverse is often true.

Important considerations for outfall construction relate to the long term integrity of the structure with a minimum of maintenance to ensure that it performs as designed. Areas which allow sedimentation should be avoided to prevent blockage of the outlet port(s). Conversely, areas subject to scour could lead to failure of the outfall.

6.3 WASTE OUTFALL INFORMATION FOR REVIEWERS

- Site hydrographic features.
- Proximity to other water users.
- Receiving water quality.
- Watercourse currents, direction, speed, duration.
- Waste stream volume and quality.
- Outfall design.
- Projected water quality within mixing zone.
- Waste plume characteristics, extent and duration.
- Aquatic habitat.
- Construction methodology.
- Construction scheduling.

6.4 WASTE OUTFALL SUPPLEMENTARY INFORMATION

- Water Quality Investigations -- Gulf Oil Canada Ltd., Clarkson Refinery, M. Griffiths, Ontario Ministry of the Environment, 1980.

- Winter Thermal Plume Study, 1979-1980 at Pickering Nuclear Generating Station, Ontario Ministry of the Environment, Ontario Hydro, Environment Canada--National Water Research Institute, March 1981.

- Marine Pipeline Installation with 'Sclairpipe', Du Pont of Canada Ltd., Pipe Division, June 1974.

- Dispersion of Effluent Plumes From Diffusers on Near-Shore Regions of the Great Lakes, Vol. I, Initial Mixing Processes, Y. Hamdy, Ontario Ministry of the Environment, August 1981.

- Dispersion of Effluent Plumes From Diffusers on Near-Shore Regions of the Great Lakes, Vol. II, Balbir Kohli, Ontario Ministry of the Environment, August 1981.

CHAPTER SEVEN
OIL AND GAS PIPELINES

7.1 DESCRIPTION

Oil and gas are commonly transported from the production source to the refinery and onto the market by pipeline. An extensive distribution network of pipelines exists in southern Ontario for natural gas.

Operating pipelines have minimal impact except in the case of leaks. For natural gas lines even underwater leaks have little direct effect on the aquatic environment.

Most oil and gas pipelines are buried in the stream or lake bottom to provide protection from scour, ice damage, and vessel traffic. Only in deep water where none of those factors are a problem will pipelines be laid on the lake bottom (as in the Lake Erie gas well connecting pipes).

7.2 OIL AND GAS PIPELINE IMPACTS AND MITIGATION MEASURES

The impacts of installing submarine pipelines relate primarily to the amount of trenching necessary to provide the required depth of cover over the pipeline. These impacts are discussed at greater length in Evaluating Construction Activities Impacting on Water Resources: Part I - Guidelines for construction of Hydrocarbon Transmission and Distribution Pipelines Crossing Watercourse. MOE, March 1984. (This document also discusses "dry" crossings which may be appropriate for smaller streams.)

In the simplest river crossing scenario with suitable bottom sediments, a trench is excavated from bank to bank and the spoils are placed to the upstream side of the trench (without bringing the spoils up through the water column and back down again). The pipeline is made up on shore and pulled into the prepared trench. The previously excavated spoils are then used as backfill over the pipeline. If the bottom sediments are contaminanted to the degree that rehandling them could cause unacceptable contaminant release to the water column, it may be necessary to remove them to a remote disposal. Any extra backfill material that may be required should be clean granular material that will not impair water quality. A surface covering of coarse rock may be required to prevent scour or damage by vessel anchors.

At the shoreline transition the bank should be left undisturbed until shortly before the pipe is actually installed and then cut just enough to allow equipment to operate. The shoreline should be promptly restored to its original contour and protected from erosion.

It is inevitable that turbidity increases will occur from underwater trenching operations. Scheduling the work to avoid critical periods of recreational use, fish spawning and migration will reduce water use conflicts. Working in periods of low flow or calm weather will reduce the area of impact. To protect critical areas in a lake (spawning shoals or water intakes) it may be possible to deploy silt curtains but in any current or waves they are seldom effective. Procedures which minimize work in the water (minimal trench, most direct route, optimal weather conditions) will result in the lowest impact on the aquatic environment.

Hydrostatic testing is a routine part of all pipeline construction. Discharge from the testing must not introduce contaminants to the watercourse or cause scour. (A watertaking permit is required from the Regional office of the Ministry of Environment six weeks in advance of any hydrostatic test for the taking of water from surface or ground sources in excess of 50,000 litres/day.)

7.3 OIL AND GAS PIPELINE INFORMATION REQUIREMENTS*

- Pipeline route (plans and profiles).
- Sediment type and quality.
- Construction methods.
- Construction scheduling.
- Other water users.
- Aquatic habitat.

7.4 OIL AND GAS PIPELINE SUPPLEMENTARY INFORMATION

- Environmental Assessment: Proposed Pipe Line Crossing St. Clair River, Beak Consultants Ltd. for Sunoco Inc., 1978.

- Rational Design of Submarine Pipelines, Robert J. Brown, World Dredging and Marine Construction, February 1971.

- Evaluating Construction Activities Impacting on Water Resources: Part I, Guidelines for Construction of Hydrocarbon Transmission and Distribution Pipelines Crossing Water Courses, Ontario Ministry of the Environment, March 1984.

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* Oil and gas pipeline projects in the Province of Ontario require the approval of an application by either the Ontario Energy Board (OEB) or the National Energy Board (NEB). All MOE concerns regarding such projects are forwarded to the OEB for inclusion, along with the concerns of other review agencies, in a coordinated response to a project application from a proponent. In most cases, then, proponents will make initial contact with the OEB to establish application procedures and regulations.

CHAPTER EIGHT
CABLE CROSSINGS

8.1 DESCRIPTION

To avoid unsightly overhead wires and in areas where the spans are too great telephone and electrical service can be provided by submarine cable. Small cables are simply laid on the bottom or ploughed into the lake bed.

Recently the technology has been developed for underwater transmission circuits carrying as much as 230 kilovolts a.c. One such installation in the Bay of Quinte is made up of 3 separate cables each about 150mm diameter. The cables consist of a conductor and a dielectic fluid (oil) under low pressure inside a polyethylene jacket. The cables are buried where it is necessary to provide protection against ice and vessel anchors.

8.2 CABLE CROSSING IMPACTS AND MITIGATION MEASURES

Installation of the small cables has a negligible impact on the environment. Some disturbance occurs at the shoreline where the cable is usually buried. The construction period including shoreline restoration can be very brief. Armour stone or equivalent protection may be applied over the cable to protect it from ice scour and boat anchors.

The high voltage lines differ primarily in scale. At Ontario Hydro's Long Reach 230kv crossing 7 cables were laid to provide two circuits and a back-up cable. Trench excavation at either shore required the removal of 2000m3 of rock and 300m3 of silt overburden. Excavation of preblasted spoils was done from shore by dragline. Silt curtains around the site prevented the spread of turbidity. Some of the excavated rock was subsequently used to cover the trench and the silt was disposed of at an approved onshore disposal.

Impacts at other sites would be a function of the amount of trenching required and the nature of the material to be excavated. As dredging projects go these projects are quite small. Where blasting is necessary, relatively small charges per delay should suffice to fracture the amount of rock to be removed. The impact on fish could be minimized by careful scheduling of the work keyed to periods when fish are not present in large numbers.

For long transmission lines, power is converted to direct current. A mass-impregnated cable having an overall diameter of 110mm has 300MW capacity at 300kv dc. This cable design was used for a submarine connection between Norway and Denmark and was selected by Ontario Hydro for their proposed Lake Erie crossing. Underwater trenching machines using cutting wheels, ploughs and hydraulic jets

are being developed which will have less impact than conventional dredging techniques.

8.3 CABLE CROSSING INFORMATION REQUIREMENTS

- Watercourse bottom profile.
- Physical and chemical characteristics of sediments.
- Cable installation design.
- Construction methods.
- Construction scheduling.
- Aquatic habitat.
- Other water users.

8.4 CABLE CROSSING SUPPLEMENTARY INFORMATION

- Environmental Impact of the Long Reach 230kv Submarine Cable Crossing, Ontario Hydro, 1983, unpublished.

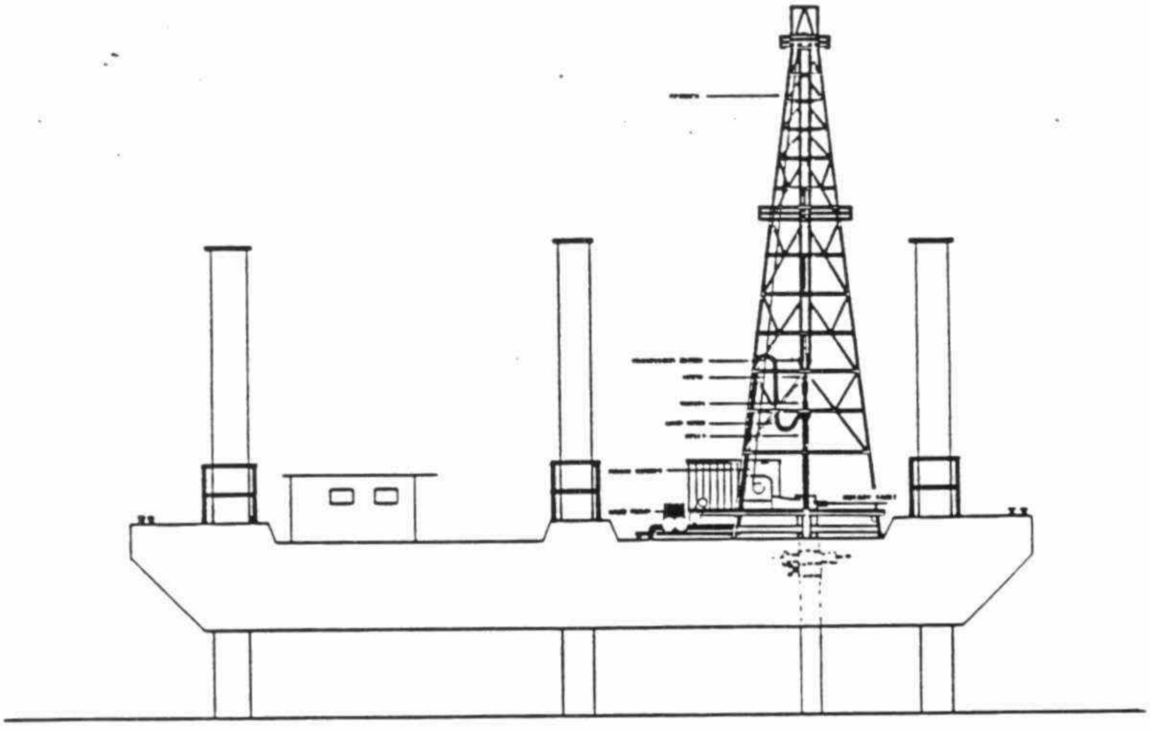
- Lake Erie Interconnection, Environmental Report, Ontario Hydro, May 1981.

CHAPTER NINE
OFFSHORE DRILLING

9.1 DESCRIPTION

Offshore drilling in the context of the Ontario region of the Great Lakes refers primarily to drilling exploration and production wells for natural gas in Lake Erie. At present some 360 producing wells in Lake Erie account for more than 70% of the total gas production in the province, (although Ontario produced less than 2% of its consumption). Ontario does not permit the development of offshore oil wells.

Once a promising formation has been identified by seismic surveys an exploratory well is drilled. Since Lake Erie water depths are not excessive (most wells are in less than 40m), the preferred drilling method is with a rotary rig on a self-elevating barge. The technology is well developed and has been practised on Lake Erie for more than 40 years. Elsewhere in the world, wells are now being drilled to 312m depths from fixed leg platforms while semi-submersibles are operating in depths to 1480m.



From: Oil and Gas in Ontario, Ontario Ministry of Natural Resources, 1967.

FIGURE 9.1 JACK-UP DRILLING PLATFORM

The rotary drill rig consists of a derrick, hoisting mechanisms to raise and lower the drill pipe, and a turntable on the derrick floor which turns the drill pipe. A drill bit on the bottom of the drill pipe grinds the rock at the bottom of the drill hole. Drilling fluid or "mud" is continuously pumped down through the drill pipe, out the bit, and back to the surface between the drill pipe and the casing. The mud cools and lubricates the bit, carries away the drill cuttings and plasters the wall of the bore hole with a stiff cake of mud to lessen the chance of a cave-in. Additionally the mud provides the hydrostatic pressure necessary to keep the well under control. The mud's main constituents are viscosifiers (bentonite), weighting agents (barium sulphate), fluid loss control agents like shredded cellophane or wood fibre, thinners such as ferrochrome lignosulphonate, and caustic soda for pH control. In special circumstances surfactants, defoaming agents, lubricants and bactericides may also be added. The bentonite typically accounts for 60 to 90% by weight of all the additives.

The drill cuttings are separated from the drilling fluid by screens and hydrocyclones and discharged. Some mud will also be discharged as it accumulates collodial particles and becomes too viscous.

The drill hole is cased at intervals as it is drilled. Several strings of casing of progressively smaller diameter may be used before the gas zone is reached.

If the well is a producing well then production casing is set down the length of the well and cemented in near the bottom of the hole. A well head on the lake bottom connects the producing well to pipelines to shore.

To stimulate the flow of gas to the well the productive formation may be acidized or fractured. Acidizing involves pumping acid down the well under pressure to dissolve channels in limestone of low permeability.

Fracturing is done by forcing sand grains in a fluid suspension under high pressure into the rock formation. The sand grains wedge the fractures open leaving the formation with greater permeability.

9.2 OFFSHORE DRILLING IMPACTS AND MITIGATION

The environmental impacts of this type of drilling are slight if good housekeeping practices are adhered to and no accidents occur.

The drill hole needs to be properly cased to prevent the possibility of fresh groundwater being contaminated with sulphurous or saline water likely to be encountered at depth.

The drilling platform must be designed to withstand the severe wave climate to which it may be exposed. Unless the platform is designed to withstand ice loadings work must be restricted to the ice-free period.

Drip pans and other collection and holding tanks shall be provided as necessary to collect fluid spills (mud, lubricants, fuels) and retain them until they can be disposed of on-shore in an approved manner.

Any oil-based drill muds must be disposed of at approved on-shore facilities.

The bulk of the discharged drill cuttings and mud descend rapidly to the lake bottom with minimal impact on water quality. No significant accumulation on the bottom would be anticipated in the shallow water energy regime of Lake Erie. Impacts on the benthos should be minor and localized.

Sewage and trash are to be disposed of at approved facilities on shore.

Re-entry holes and abandoned holes should be plugged so that fluids from one level will not migrate to other levels or to surface waters.

Well heads should be recessed into the lake bottom such that they do not obstruct commercial fishing.

9.3 OFFSHORE DRILLING INFORMATION REQUIREMENTS FOR REVIEWERS

- Well location.
- Drilling methodology.
- Contingency provisions.
- Aquatic habitat.
- Presence of commercial fishing.
- Disposal provisions for waste fluids, trash, sewage.
- Proximity to water intakes.
- Estimate volumes of drilling fluid and drilling cuttings to be discharged.
- Indicate makeup and toxicity of drilling fluid.

9.4 OFFSHORE DRILLING SUPPLEMENTARY INFORMATION

- Oil & Gas in Ontario, Ontario Ministry of Natural Resources, 1967.

- The Environmental Implications of Offshore Oil & Gas Activities, Charles A. Menzie, Environmental Science and Technology, Vol. 16, No. 8, 1982.

- Offshore Oil Drilling, Environmental Science & Technology, Vol. 15, No. 11, 1981.
- Deepwater Drilling and Production Technology, Ronald L. Geer, Marine Technology Society Journal, Vol. 16, No. 2, 1982.

CHAPTER 10
SUBAQUEOUS MINING

10.1 DESCRIPTION

Subaqueous mining in the Great Lakes has been largely confined to the removal of sand and gravel from nearshore and beach deposits. Mining may be accomplished by landbased equipment like draglines or by offshore equipment like suction hopper dredges.

10.2 SUBAQUEOUS MINING IMPACTS AND MITIGATION MEASURES

The direct impacts of subaqueous mining are related to the type of equipment used. Those impacts are discussed more fully in the Evaluating Construction Activities Impacting on Water Resources: Part III, Guidelines for Dredging and Dredged Material Disposal.

Briefly, there are two categories of dredging plant; mechanical and hydraulic. In the former category are dragline and clamshell excavators which may be either on land or barge mounted. Hydraulic dredges are normally floating plant equipped with centrifugal pumps to move solids in a slurry form either via pipeline or into self-contained hoppers. The hydraulic dredge may have a powered cutterhead on the suction pipe to loosen compacted material.

Mechanical dredges pick up bottom sediments with a minimum of entrained water. When excavating in sands and gravels turbidity increases are localized and short term.

Hydraulic dredges typically pump only 10 to 20% solids. In a sand and gravel mining operation, where the material is pumped ashore, the excess water will be discharged back to the water-course after the desirable sized solids have been removed. If the source material contains silt-sized particles, it may be necessary to run the effluent through settling ponds to minimize the suspended solids discharge to the watercourse. When the suction dredge is equipped with on-board hoppers, the normal practice is to continue pumping slurry into the hoppers, allowing water and fine particulate to overflow back into the watercourse until an economic load is obtained.

Regardless of the dredging methodology, turbidity increases may be substantial when silt or clay-sized particles are present in the source material. To avoid conflict with other water users, it may be necessary to restrict dredging activities near water intakes and recreational areas.

Any subaqueous mining operation will disrupt the aquatic habitat particularly the benthic habitat. Gravel, and to some extent sand deposits, may represent important fish spawning and feeding areas and merit careful evaluation. Knowledge of the life cycle of resident species might allow extraction to proceed on a seasonal basis. Changes in sediment type through extraction of sands and gravels should generally be avoided. It is undesirable, for example, to remove all deposits of sand and leave in its place the settled-out silts.

Removal of material from the littoral zone has the potential to disrupt littoral processes. In particular the extraction of beach feeding sands may exacerbate shoreline erosion. Mineral extraction should be limited to areas of deposition such as river mouths or offshore.

At some locations anthropogenic loadings will have introduced contaminants and silts to otherwise desirable aggregates. The normal extraction procedure, either at the barge or on shore, will release many of the contaminants to the water with the rejected fine-grained particulates. This release may be an unacceptable environmental alternative to leaving the contaminated aggregate in place to be subsequently buried by cleaner material. In intermediate cases the on-shore processing could be modified to retain more of the contaminants and provide adequate permanent disposal for them.

10.3 INFORMATION REQUIREMENTS FOR REVIEWERS

- o Location and size of mineral deposit.
- o Physical characteristics of deposit.
- o Historical formation of deposit and relationship to littoral processes.
- o Aquatic habitat
    - * fish community
    - * benthic habitat
    - * chemical quality of sediments.
- o Other water uses
    - * location of intakes and outfalls
    - * recreation.
- o Proposed extraction methodology.
- o Scheduling.

10.4 SUPPLEMENTARY INFORMATION

- o Guidelines and Register for Evaluation of Great Lakes Dredging Projects, Report of the Dredging Subcommittee to the Great Lakes Water Quality Board, International Joint Commission, January 1982.

- o International Working Group on the Abatement and Control of Pollution from Dredging Activities, May 1975.

- Report of the Lake Shore Erosion Conference, The Niagara-Toronto Lake Shore Protective Association, March 10, 1948.

- Evaluating Construction Activities Impacting on Water Resources: Part III, Guidelines for Dredging and Dredged material Disposal. MOE 1985.

CHAPTER ELEVEN
UNDERWATER BLASTING

11.1 DESCRIPTION

Underwater blasting is undertaken for three primary reasons; rock excavation, demolition, and seismic surveying. In its most common application, rock excavation, explosives are usually placed in drilled holes to fragment rock into pieces suitable for subsequent excavation by a dredge. The fragmentation size and the rock type will determine the blast ratio. Typical blast ratios range from 0.5 kg explosive/cubic metre in soft sedimentary rock to 1.8 kg/m3 in granite.

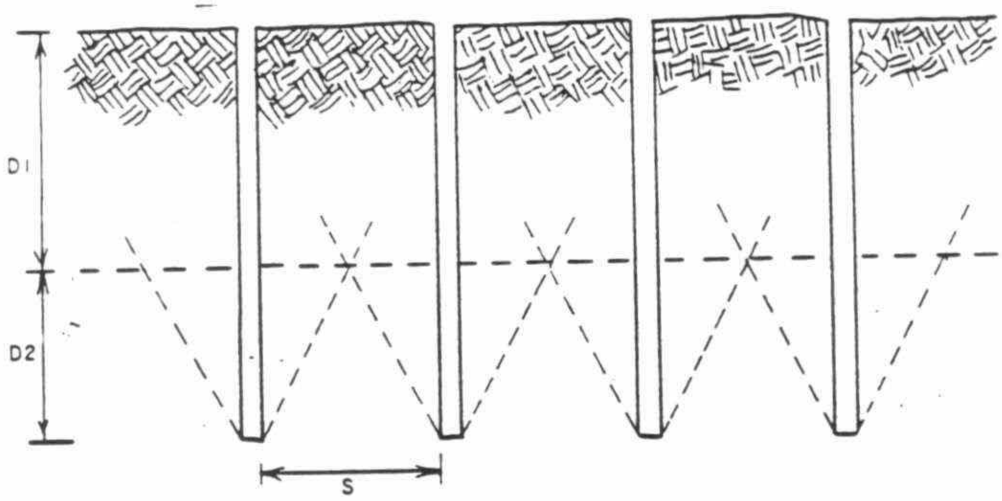


FIGURE 11.1 DRILLING PATTERN

The additional depth (D2) drilled below the excavation depth (D1) to get fracturing to the excavation depth is approximately equal to the spacing between holes (S).

For underwater demolition work, the explosive charges will more likely be placed on the surface of the object to be demolished (ex. boulders, sunken vessels obstructing navigation). Such blasting is less effective since it depends entirely on the shattering effect of the detonation wave and the gases produced are largely dissipated in the water. Shaped charges improve this performance but their expense limits them to special applications (like cutting off pilings).

In seismic surveys, explosives may be detonated in the water column or on the bottom to serve as an acoustic source for subsequent measurements of reflected and refracted energy.

11.2 BLASTING IMPACTS

An underwater explosion produces a positive pressure wave immediately followed by a negative pressure wave. This sudden change in pressure can be lethal to fish in the vicinity. The rate of pressure change appears to determine lethality more than the magnitude of the pressure change. The rate of pressure change is determined by an explosive's characteristic detonation velocity, some of which are shown below:

Black powder blasts have little effect on fish. Monitored overpressures as high as 1100 Kpa have not produced mortalities compared to minimum lethal pressures in the range of 276 Kpa for dynamite and 30 to 150 Kpa for C.I.L. Hydromex.

Charges placed in a stemmed drill hole lose most of their energy fracturing the rock and thus produce smaller pressure changes than unconfined charges.

The peak overpressure can be approximated by the following formula developed by R.H. Cole (1948)

$$P = f \left(\frac{W^{0.33}}{R}\right)^{1.14}$$

where P = Peak overpressure in KPa.
W = Weight of explosive per delay period in kg.
R = Distance between shot and observation point in m.
f = an experimentally determined constant.

In 54 overpressure measurements at Nanticoke during construction of the Stelco dock in 1975, VME Associates determined f to be 733.7 for those site conditions and Hydromex explosive. Observations of caged and resident fish indicated an overpressure range associated with acute internal injury to fish was 30 Kpa to 150 Kpa. 100% mortality occurred over radii from 20 to 45m and 10% to 20% mortality at 45m to 110m (for blasts as great as 272kg per delay).

The injuries fish sustained were ruptured swim bladders and hemorrhaging in the coelomic and pericardial cavities. Laterally compressed species (white bass, pumpkinseed) were more susceptible to blast pressure gradients than were the fusiform fishes (rainbow trout, white sucker). Swim bladders often burst outward suggesting the fish withstood the positive pressure wave then succumbed to the negative.

About half of the fish killed in an underwater blast will sink rather than float to the surface.

Some injured fish will survive for several hours and thus not be observed in a post blast mortality survey. Stunned fish which might otherwise survive their injuries are very vulnerable to herring gull predation.

Unburied charges have a higher fatality radius than buried charges. In an experimental application of shaped 9kg high explosive charges set on rock bottom in Lake Erie in 1976 the lethal radius has been estimated at 122m. Ferguson reports fish kills 60m from only 0.5kg of high explosive. Falk and Lawrence indicate that a lethal radius as great as 914m has been reported for 1814kg of Geogel (high explosive) placed on the lake bottom.

By comparison the 1958 explosion of 1,247,379kg of Dupont Nitramex 2-H buried under Ripple Rock reportedly had a lethal radius of only 805m.

In some instances the lethal radius for buried charges has been reported as being smaller near the bottom than in surface waters. This may be related to the propogation of the pressure wave, the fact the fish in the water column are more likely to have swim bladders and are thus more susceptible than bottom fish or may simply reflect the difficulty of adequately surveying the bottom fish.

Sculpins, crayfish, clams and snails have been observed within 5m of a high explosive blast minutes after the detonation showing no ill effects.

Structural damage caused by blasting is usually the result of vibration. Energy from the detonated explosive is transmitted from one particle to another as elastic waves. The resulting movement in the rock and overlying structures is inversely proportional to the distance from the blast. Damage is more a function of particle velocity than of amplitude. A particle velocity of 5cm/sec. is considered a safe level of vibration for normal residential structures. Bridges, dams and docks should be able to safely withstand velocities of 15cm/sec.

The third cause of damage from blasting (after water pressure and vibration) is flying rock. This is not usually a problem in underwater blasting unless the overlying water is less than 3m deep.

The direct water quality impact of detonating explosives underwater is minimal. There may be short term increases in nitrites and carbon dioxide but these disperse rapidly. The indirect effect of mixing poor quality sediment overburden into the water column is seldom significant in rock excavation areas.

11.3 BLASTING IMPACT MITIGATION MEASURES

When blasting rock (or hard till etc.) the adverse affect on fish will be minimized by avoiding the release of energy beyond that needed to break the rock. To achieve this end charges placed in drilled holes and stemmed are preferrable to surface charges.

Monitoring of blasting operations over several weeks at South Baymouth and Nanticoke found that fish mortality declined after the

first few blasts. It is postulated that elevated levels of turbidity from the drilling and blasting caused fish to avoid the area. This effect may be species dependant as some of the literature suggests predators move into the area to feed on killed fish and were themselves killed in subsequent blasts. A careful evaluation of the habits of fish species occurring in an area can help devise a blasting program having minimal effects.

A solid object in the path of a pressure wave reduces the lethal range of a blast in that direction. The underwater topography of a site may be used to advantage to reduce the blast impact. The production face can be oriented away from sensitive areas.

Using the formula provided in Chapter 11.2 it is possible (after determining the site coefficient f and assuming a lethal overpressure) to determine the lethal radius for a given size of explosive charge. Alternatively, to protect a habitat at a given distance from the blast the maximum charge size can be calculated.

In extreme cases an air bubble curtain can markedly reduce the pressure created by a blast. For open water production blasting, however; air curtains are difficult and expensive to deploy.

The most effective mitigative measure applicable to seismic work is the selection of a non-explosive acoustic source. Three of the more popular devices are described below:

Par Air Gun uses a sudden release of air under high pressure. Lethal radius is estimated at 1m to 2m. Shock wave is similar to that from black powder. Tests by the Canada Department of Energy, Mines and Resources showed that a 1000 cubic inch (16,387 cm^3) Air Gun was as effective as 50lb. (22.68kg.) dynamite charges as a seismic source.

Vaporchoc -- Steam is injected at 6 to 12 second intervals into the waterbody to form large bubbles. The bubble collapses as the steam condenses and the rapidly inflowing water produces an acoustic output.

Flexotir -- A 2oz. (56.68g) explosive charge is detonated inside a 2ft. (0.61m) diameter cast iron sphere 2in. (50.8mm) thick perforated with 13 holes about 2in. (50.8mm) in diamater. The sphere damps the bubble oscillation allowing the device to be considered non-explosive.

11.4 BLASTING INFORMATION REQUIREMENTS FOR REVIEWERS

- o Physiography of work site.
- o Presence or absence of overburden, aquatic vegetation.
- o Physical and chemical quality of any overburden.
- o Bedrock geology.

- o Aquatic habitat characteristics:
  - * resident fish species
  - * migratory fish species and migratory periods
  - * presence of spawning habitat.
- o Work schedule.
- o Blasting patterns and ratios.
- o Other water uses.
- o Nearby land uses.

11.5 SUPPLEMENTARY INFORMATION SOURCES

- o Environmental Impact Study, Underwater Blasting Operations During Construction of the Stelco Dock Facility, Nanticoke Ontario, VME Associates, September 30, 1976.

- o The Acute and Sub Acute Effects of Underwater Rock Blasting and Dredging on the Fishes in Long Point Bay, Lake Erie, Report No. 1, Construction Phase 1, March-November 1975, Allan J. Chamberlain, Ministry of Natural Resources, April 1976.

- o Acute Effects of Underwater Construction Blasting on Fishes in Long Point Bay, Lake Erie, G.C. Teleki and A.J. Chamberlain, Journal of Fisheries, Research Board of Canada, Vol. 35, 1978. pp. 1191-98.

- o Fish Mortality Studies, Tobermory Ferry Project, Ministry of Transportation and Communications, Environmental Office, April 1974.

- o Seismic Exploration: Its Nature and Effect on Fish, M.R. Falk and M.J. Lawrence, Fisheries and Marine Service, Canada Department of the Environment, Technical Report Series No.: CEN/T-73-9, 1973.

- o Underwater Drilling and Blasting, W.R. Morrison, World Dredging and Marine Construction, October 1974.

- o Biological Effects of the Ripple Rock Explosion, J.A. Thomson, Biological Station, Nanaimo, B.C., Fisheries Board of Canada, 1958.

- o The Effects of Underwater Explosions on Yellow Perch, R.G. Ferguson, 1962 Canadian Fish Culture, Vol. 29, pp. 31-39.

APPENDIX I
SEDIMENT QUALITY EVALUATION GUIDELINES* (MOE, 1976)

GUIDELINES

For MOE evaluations of dredging projects, the following guidelines are suggested as indicative of contaminated sediments subject to the limitations outlined previously.

VOLATILE SOLIDS (Loss on ignition at 600°C)	6%
COD	5%
TOTAL KJELDAHL NITROGEN	0.2%
TOTAL PHOSPHORUS (As P)	0.1%
OIL AND GREASE	0.15%
PCB's	0.05 ppm
MERCURY	0.3
LEAD	50 ppm
ZINC	100 ppm
CHROMIUM	25 ppm
COPPER	25 ppm
ARSENIC	8.0 ppm
CADMIUM	1.0 ppm
CYANIDE	0.1 ppm
AMMONIA	100 ppm
NICKEL	25 ppm
COBALT	50 ppm

(Analyses must be on a dry weight basis (i.e. ug/g).

* Details on sediment quality evaluation will be found in Evaluating Construction Activities Impacting on Water Resources Part III - Guidelines for Dredging and Dredged Material Disposal.

APPENDIX II
REGULATIONS AND PERMITS RELATED TO MARINE CONSTRUCTION TYPE ACTIVITIES

A. FEDERAL

Environmental Assessment and Review Process

During 1974 the Department of Environment introduced the Environmental Assessment and Review Process (EARP) thereby providing for the administrative co-ordination of environmental matters in all federal programs and activities as well as in projects for which federal funds or property are required.

The Federal Environmental Assessment Review Office (FEARO) administers the Environmental Assessment and Review Process (EARP) on behalf of the Minister of Environment Canada. This assessment process determines the probable environmental impact of proposed development projects, to assure adequate protection for the environment and the needs of the local community. Public hearings are a central part of the review process, and provide opportunities for mutual education of both the proponents of the activity in question and members of communities directly affected. The recommendations to the minister by the panels conducting the hearings have often resulted in alterations to project designs or, on occasion, abandonment or postponement of projects.

Navigable Waters Protection Act

The Navigable Waters Protection Act (R.S.C. 1970 Chapter N-19) is one of the statutes through which the Federal Government has exercised its jurisdiction over navigation and is designed to protect water, as defined in the Statute, by prohibiting the building or placement of any work in, upon, over, under, through, or across a navigable water without the approval of the Minister of Transport. According to the Act, work includes *** any dumping of fill or excavation of materials from the bed of a navigable water. *** Generally the Act can control dredging and dumping but this could result from different sections of the Act depending on the circumstances.

An approval granted by the Minister in respect of a work and the site and plans pursuant to this Act is only an authorization to interfere with the public right of navigation to the extent of the work for which site and plans have been approved. The approval of the Minister is not an approval for construction nor an authorization in respect of any statute, regulation or bylaw, federal, provincial or municipal which may require some other form of authorization in respect of construction, land use, noise, weed or pollution control, zoning or like matters; nor

does such approval of the Minister vest in the recipient any title, easement, restriction or other property rights in respect of the land on which the work is to be placed or in respect of any property adjacent to or in the vicinity of the work.

The Harbour Commissions Act

The Harbour Commissions Act, Chapter H-1 of the Revised Statutes of Canada, provides for the establishment of a harbour commission for any harbour in Canada that is not named in the National Harbour Board Act, or for any harbour for which a harbour commission has not otherwise been established by Parliament. Such a commission has the power to regulate dredging within its harbour. However, Section 29 of the Harbour Commission Act recites that, *** any work undertaken by or on behalf of the Commission affecting the use of any navigable water is subject to the Navigable Waters Protection Act.

The National Harbours Board Act

The National Harbours Board Act, Chapter N-8 of the Revised Statutes of Canada provides the Board with jurisdiction over any harbours which may be transferred to the Board. The Board has power to control dredging. Section 37 of the Act requires compliance with the Navigable Waters Protection Act and both Ministers of Transport and Public Works must approve the works jointly. There are also other federal acts that establish harbour commissions for particular harbours and which, similarly, could control dredging and marine construction.

The Public Works Act

Section 9 of the Public Works Act reads in part:

9(1) The Minister has the management, charge and direction of the following properties belonging to Canada, and of the services in this section enumerated, namely:

(a) the dams, the hydraulic works, the construction and repair of harbours, piers and works for improving the navigation of any water, and the vessels, dredges, scows, tools, implements and machinery for the improvement of navigation.

Section 37 of the Act reads as follows:

Whenever the Governor in Council, or the Minister charged with any work for the improvement of navigation, directs any work to be performed in any navigable water for the improvement of the navigation thereof, it is lawful for the officers or servants of Her Majesty or the contractors for the work, under the direction of the Governor in Council or of the Minister, to enter upon, dig up, dredge and remove any part of the bed of such navigable

water, or to build or erect any works thereon, as may be directed or authorized by the Governor in Council or by the Minister for the improvement of the navigation.

Without this section the dredging by officers, servants or contractors of the Federal Crown could result in trespass since the bed of a navigable water may be owned by the provincial government or another person.

The Fisheries Act

Section 91(12) of the BNA Act gives the Federal Government jurisdiction over sea cost and inland fisheries. In Ontario, and several other provinces, the Federal Government has delegated to the province the administration of the Federal Fisheries Act.

Subsection 33(2) is the general anti-pollution provision of the Fisheries Act and states *** no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish. *** Deleterious substance is given a very broad meaning under Subsection 33(11).

Section 33(1) prohibits the throwing overboard of ballast, coal ashes, stones, or other prejudicial or deleterious substances in any river, harbour, roadstead, or in any water where fishing is carried on.

Migratory Birds Convention Act

Control over dredging might also be derived from regulations under the Migratory Birds Convention Act. Section 51 thereof, states:

> No person shall place, cause to be placed or in any manner permit the flow or entrance of oil, oil wastes or substances harmful to migratory birds into or upon waters or upon the ice covering such waters.

B. PROVINCIAL

Dredging and marine construction may be affected by the following Ontario Acts:

The Environmental Assessment Act

The purpose of the Act is "the betterment of the people of the whole or any part of Ontario by providing for the protection, conservation and wise management in Ontario of the environment". It is administered by the Ministry of the Environment.

The Act applies to all undertakings of the public sector unless they are exempted from compliance, temporarily or permanently, by regulation or order.

Where the Act applies to an undertaking, its proponent is required to submit an environmental assessment of the undertaking to the Minister, and cannot proceed until the assessment has been accepted and the undertaking approved. Licenses, approvals, loans, etc. under other Acts may not be granted until the environmental assessment has been accepted and the undertaking approved by the Minister.

The assessment must contain a description of the purpose of the undertaking; its rationale, including alternate methods and alternatives to the project itself; a description of the environment expected to be affected; the effects of the undertaking; and measures to mitigate the effects of the undertaking, the alternate methods, and the alternatives; an evaluation of the advantages and disadvantages to the environment of the undertaking, the alternate methods, and the alternatives.

The Ontario Water Resources Act

The direct control of resources gives the Province jurisdiction over water and air pollution and other environmental matters. Subsection 32(1) of the Ontario Water Resources Act prohibits the discharge or deposit of any material of any kind into water that may impair the quality of the water. This subsection gives the Ontario Ministry of the Environment authority to require that the dredged material be disposed so that it does not pollute the waters. In practice, the Ministry of the Environment advises by letter whether the work contemplated may impair the quality of the water and the water quality which should be maintained. The Ministry does not issue a permit but rather advises the applicant what it considers acceptable within the terms of the Ontario Water Resources Act.

The Environmental Protection Act

The Environmental Protection Act contains general provisions for the control of all contaminants being discharged to any part of the natural environment.

The Beds ~~of~~ Navigable Waters Act

The Beds of Navigable Waters Act recites that, with certain exceptions, the beds of navigable waters, in the absence of an express grant of title, remain the property of the provincial crown. In some cases the bed of the waterbody might be owned by the Federal Department of Transport or Department of National Defence and then application for acquisition of the land would have to be made to the appropriate authority. Dredging opera-

tions are often done in conjunction with other construction activities and in such cases it is necessary for an applicant if other than a federal agency, to obtain title to the bed of the waterbody.

Public Lands Act

Whenever the bed of a waterbody in question is owned by Ontario, an appropriate application should be made under the Public Lands Act (Revised Statutes of Ontario 1970, Chapter 81). Section 29 of the Act makes it an offence to deposit any material upon public lands, whether or not covered by water, without the written consent of the Minister or authorized officer. Section 45 allows the Minister to sell, lease, or issue a licence of occupation in respect to public lands covered with water.

The Conservation Authorities Act

Section 27(1) of the Conservation Authorities Act gives conservation authorities considerable power to control waterways within their jurisdiction. This Section states in part:

> Subject to the approval of the Lieutenant Governor in Council, an authority may make regulations applicable in the area under its jurisdiction
>
> (a) restricting and regulating the use of water in or from rivers, streams, inland lakes, ponds, swamps, and natural or artificially constructed depressions in rivers or streams;
>
> (b) prohibiting or regulating the straightening, changing, diverting or interfering in any way with the existing channel of a river, creek, stream or watercourse;
>
> (c) regulating the location of ponds used as a source of water for irrigation;
>
> (d) providing for the appointment of officers to enforce any regulation made under this section;
>
> (e) prohibiting or regulating the construction of any building or structure in or on a pond or swamp or in any area below the high water mark of a lake, river, creek or stream;
>
> (f) prohibiting or regulating the placing or dumping of fill of any kind in any defined part of the area over which the authority has jurisdiction in which in the opinion of the authority the control of flooding or pollution or the conservation of land may be affected by the placing or dumping of fill.

Any regulations made under Subsection 27(1)(f) would substantially affect any dredging and marine construction project within an established conservation area.

The Beach Protection Act

The Beach Protection Act controls the removal of sand and gravel from the bed, bank, beach, etc., of waterbodies. This Act is intended to protect beaches and the property rights that the province has in such sand and gravel. Section 3 prohibits any person from carrying away or removing by dragline or other mechanical device any sand from a bed, bank, or shore unless the person has a licence. Section 9 provides the power to make regulations to prohibit or restrict the removal of sand from the shores of Lakes Ontario, Erie and Huron.

The Public Health Act

Secion 95a of the Public Health Act places certain controls on waste disposal which could include dredged material. Subsection 95a(11) prohibits disposal of wastes without a certificate. A medical officer of health may order the removal of wastes if the disposal was not approved. This section could be applied to the disposal of materials that are contaminated particularly if they are to be disposed of in a populated area. The disposal of such material could be controlled by requiring a certificate of approval under the Waste Management Act.

The Lakes and Rivers Improvement Act

Section 10 of the Lakes and Rivers Improvement Act prohibits construction of a dam on any lake or river until both the location of the dam and its specifications have been approved by the Minister of Natural Resources. A dam is defined in general terms as a work forwarding, holding back or diverting water.

GLOSSARY

Benthic Invertebrates - All animals except fishes and amphibians, (and reptiles, birds and mamals) whose habitat is the bottom of a lake or river.

Biota - The plant and animal assemblage of a given community.

Breakwater - A structure protecting a shore area, harbour anchorage or basin from wave action.

Bulkhead - A steep or vertical wall retaining an embankment.

Causeway - A road carried over marsh or water by an earth or rock fill.

Cofferdam - A temporary dam built to exclude water from an area that has been pumped dry and thus provide access to an area which is ordinarily submerged.

Clean Fill - For the purpose of this report shall be earth, rock, and rubble which meets the Ministry of the Environment's sediment quality guidelines for open water disposal of dredge spoils (Appendix I).

Downdrift - The direction of the predominant movement of littoral materials.

Epibenthos - The fauna and flora of the nearshore lake bottom.

Ecosystem - A community, including all the component organisms, together with the environment, forming an interacting system.

Fauna - A collective term for the animal species present in an ecosystem.

Gabion - A prefabricated wire mesh basket available in a variety of sizes assembled and filled with rock on site.

Geomorphology - That branch of both physiography and geology which deals with the form of the earth, the general configuration of its surface, and the changes that take place in the evolution of land forms.

Groyne - A shore protection structure built out at an angle from shore to trap sand and to protect the shore from erosion due to currents and waves by making a beach.

Hardpoint - A point of land resistant to erosion by virtue of its geology or artificial reinforcement.

Hydrostatic Testing - Pressure testing of sections of oil, gas, water and sewer pipelines by filling them with water under pressure and testing for leaks.

Lakefill - A land mass created by dumping earth and rubble fill into a lake.

Leachate - A liquid filtered down through some material.

Longard Tube - A proprietary fabric mesh cylinder filed on site usually by hydraulically placed sand.

Littoral Drift - The material moved along beaches and in the nearshore zone by the prevailing currents and oblique waves.

Littoral Transport - The movement of littoral drift in the littoral zone by waves and currents including movement parallel to the shore (longshore transport) and perpendicular to the shore (onshore-offshore transport).

Littoral Zone (Physiographic) - The area extending from the outermost breaker or where wave characteristics significantly alter due to decreased depth of water to: either the effective limit of storm waves (usually the line of permanent vegetation); or the limit of wave uprush at average annual high water level.

Littoral Zone (Biological) - The shallow water region with light penetration to the bottom which may sustain rooted plants.

Nodal Zone - An area at which the predominant direction of the littoral transport changes.

Physiographic Unit - An area having a particular pattern of relief features or land forms that differs significantly from that of adjacent areas.

Pier - A structure extending from shore out into the water, to serve as a landing place, a recreational facility, etc., rather than to afford coastal protection.

Revetment - A sloping protective facing of stone, concrete, etc. built to protect an embankment or shore structure against erosion by wave action or currents.

Rip-rap - Stones, typically from 7 to 70 kg, randomly placed in a revetment.

Rubble - Rough, irregular fragments of broken rock, concrete and brick.

Soldier Pile - A steel rolled section driven into the ground to carry the force from a horizontal sheeted earth bank.

Substrate - The base on which an organism lives

Topography - The configuration of a surface including its relief, the position of its streams, roads, buildings, etc.

Wetlands - Land where the water table is at, near, or above, the land surface long enough to promote the formation of hydric soils or to support the growth of plants which grow only in water or saturated soils.